JOURNAL OF THE A·I·E·E·

MARCH — 1930

AIEE

PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

MEETINGS

of the

American Institute of Electrical Engineers

NORTH EASTERN DISTRICT MEETING No. 1, Springfield, Mass., May 7-10, 1930

SUMMER CONVENTION, Toronto, Ontario, Canada, June 23-27, 1930

PACIFIC COAST CONVENTION, Portland, Oregon, September 2-5, 1930

MIDDLE EASTERN DISTRICT MEETING, No. 2, Philadelphia, Pa., October 13-15, 1930

SOUTHERN DISTRICT MEETING, No. 4, Louisville, Kentucky, November 19-22, 1930

MEETINGS OF OTHER SOCIETIES

Northwest Electric Light and Power Association Engineering Section, Aberdeen, Wash., March 26-28. (B. Snow, 1206 Spalding Bldg., Portland, Ore.)

The American Society of Mechanical Engineers 50th Anniversary Meeting, April 5-9, New York, N. Y., and Washington, D. C. (C. W. Rice, Secretary, 29 West 39th St.)

American Electrochemical Society, St. Louis, May 29-31. (C. G. Fink, Columbia University, New York)

JOURNAL of the A. I. E. E.

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, New York

PUBLICATION COMMITTEE
W. S. Gorsuch, *Chairman*, H. P. Charlesworth, F. L. Hutchinson, A. E. Knowlton, E. B. Meyer

George R. Metcalfe, *Editor*

Changes of advertising copy should reach Institute headquarters by the 15th day of the month for the issue of the following month.

Subscription: $10.00 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippines, $10.50 to Canada, Central America, South America, Haiti, Spain and Colonies, and $11.00 to all other countries. Single copies $1.00.

Entered as matter of the second class at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress, March 3, 1879. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

Vol. XLIX MARCH 1930 Number 3

TABLE OF CONTENTS

Papers, Discussion, Reports, Etc.

Institute and Related Activities

A REQUEST FOR CHANGE OF ADDRESS must be received at Institute headquarters at least ten days before the date of issue with which it is to take effect. Duplicate copies cannot be sent without charge to replace those issues undelivered through failure to send such advance notice. With your new address, be sure to mention the old one, indicating also any changes in business connections.

American Institute of Electrical Engineers

—Some Activities and Services Open to Members—

Conventions.—The Institute holds three national conventions each year; the Winter Convention in January, the Summer Convention in June, and the Pacific Coast Convention usually in September.

Employment Service.—The employment service is a joint activity administered by the Civil, Mining, Mechanical, and Electrical Engineering societies and is available to the membership of these societies. Branches of this Department are located in Chicago and San Francisco, the main office being located at the societies headquarters in New York. The service is designed to be mutually helpful to engineers seeking employment, and concerns desiring to secure the services of engineers. This department is financed by contributions from the societies maintaining it and from beneficiaries of the service. Further details will be furnished on request to the Managers cf the Employment Service at the main or branch offices, addresses of which will be found elsewhere in this issue.

Scope of Papers—Institute papers should present information which adds definitely to the theoretical or practical knowledge of electrical engineering and may be derived from activities in any of its branches. Acceptable subject matter is as follows: New theories or new treatments of existing theories; Mathematical solution of electrical engineering problems; Researches, fundamental or practical; Design of equipment, and of electrical engineering projects; Engineering and economic investigations; Operation and tests of electrical equipment or systems; Measurements of electrical quantities; Electrical measurement of non-electrical quantities; Applications of electricity to industrial or social purposes; Education; Standardization; Cooperative engineering organizations; Ethical and social aspects of the profession.

Attendance at Conventions.—Taking part in the Institute conventions is one of the most useful and helpful activities which membership in the Institute affords. The advantages offered lie in two distinct channels; technical information and personal contacts. The papers presented are largely upon current problems and new developments, and the educational advantages of hearing and taking part in the discussion of these subjects in an open forum cannot but broaden the vision and augment the general knowledge of those who participate. Equally advantageous is the opportunity which conventions afford to extend professional acquaintances and to gain the inspiration which grows out of intimate contact with the leaders in electrical engineering. These conventions draw an attendance of from 1000 to 2000 people and constitute milestones in the development of the electrical art.

To Members Going Abroad.—Members of the Institute who contemplate visiting foreign countries are reminded that since 1912 the Institute has had reciprocal arrangements with a number of foreign engineering societies for the exchange of visiting member privileges, which entitle members of the Institute while abroad to membership privileges in these societies for a period of three months and members of foreign societies visiting the United States to the privileges of Institute membership for a like period of time, upon presentation of proper credentials. A form of certificate which serves as credentials from the Institute to the foreign societies for the use of Institute members desiring to avail themselves of these exchange privileges may be obtained upon application to Institute headquarters, New York.

The societies with which these reciprocal arrangements have been established and are still in effect are: Institution of Electrical Engineers (Great Britain), Societe Francaise des Electriciens (France), Association Suisse des Electriciens (Switzerland), Associazione Elettrotecnica Italiana (Italy), Koninklijk Instituut van Ingenieurs (Holland), Verband Deutscher Elektrotechniker E. V. (Germany), Denki Gakkwai (Japan), Norsk Elektroteknisk Forening (Norway), Elektrotechnicky Svaz Ceskoslovensky (Czechoslovakia), and The Institution of Engineers, Australia (Australia).

Library Service.—The Engineering Societies Library is the joint property of the four national societies of Civil, Mining, Mechanical, and Electrical Engineers and comprises one of the most complete technical libraries in existence. Arrangements have been made to place the resources of the library at the disposal of Institute members, wherever located. Books are rented for limited periods, bibliographies prepared on request, copies and translations of articles furnished, etc., at charges which merely cover the cost of the service. The Director of the library will gladly give any information requested as to the scope and cost of any desired service. The library is open from 9 a. m. to 10 p. m. every day except holidays and during July and August, when it closes at 5 p. m.

JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

Vol. XLIX MARCH, 1930 Number 3

A Message From the President.

STANDARDS

AT the meeting of the Board of Directors held January 29th, important action was taken concerning the standards work of the Institute. This matter is of so much importance that the attention of members should be called to it at this initial stage of the movement to invite their thoughtful consideration. The resolutions adopted by the Directors follow:

The American Institute of Electrical Engineers, recognizing that other organizations in the electrical industry have the same fundamental interest in electrical standardization as the A. I. E. E., namely, aiding in and guiding the proper development of the electrical industry in the United States, hereby

RESOLVES: That the American Institute of Electrical Engineers approves in principle the formation of a joint agency of the electrical industry for the purpose of carrying out the necessary standardization activities of that industry.

It is contemplated that this agency shall have three distinct functions:

a. The Electrical Standards Committee of the Electrical Industry in the United States of America.

b. The Electrical Advisory Committee of the American Standards Association.

c. The United States National Committee of the International Electrotechnical Commission and of any other international organizations for the handling of electrical matters.

RESOLVES: That the President of the A. I. E. E is hereby authorized to take appropriate steps to propose this action to the interested electrical associations, preferably through the Electrical Advisory Committee of the American Standards Association.

AND FURTHER RESOLVES: That the Institute declares it to be its intention that on the consummation of an organization satisfactory to the Institute for this purpose, the Institute, in general, will refer to that body the consideration and approval of standards in which it is interested.

It will be noted that the only step taken at this time is to propose and endorse a contemplated and appropriate action. If the proposal is favorably considered by other electrical associations, an organizing committee will be formed which will determine the character and powers of the proposed industry standards committee. Consequently details are not involved at present and the only purpose at this time is to call attention to the general situation and to present some of the reasons that led the Directors to take this initial step.

Conditions in the electrical standards field have changed greatly during the past ten or fifteen years. In the early years of standards activity the Institute was the only organization active in preparing electrical standards. There was a need which the Institute recognized and filled acceptably. In the international field, when the International Electrotechnical Commission was formed, the Institute also became responsible for the U. S. National Committee.

Mainly during the past ten years commercial associations and the U. S. Government have developed active interest in standards. The A. S. A. has been formed and expanded and the U. S. Committee of the I. E. C. has been made autonomous. In both these latter developments the Institute has had a major responsibility. As a result of these changes many new interests have been developed in the standards field and these interests have overlapped and jurisdictional difficulties have arisen.

The word "Standard" implies a single authority to set up standards. With many bodies in the electrical field setting up standards, more or less independently, there has been unnecessary duplication of effort, unnecessary expenditures of time and money, and, in some instances, a defeat of the very purpose of establishing a common standard.

The organization of the American Engineering Standards Committee twelve years ago was a forward step for which the Am. Inst. of E. E. was largely responsible. It has occupied a part of the field above that now under consideration. The foundation of *its* work has been the standards of organizations such as the Institute. The AESC and its successor (ASA) starts where the electrical organizations stop. It has been able to do little (by reason of constitutional limits) to eliminate duplication and jurisdictional difficulties among its member associations. As existing A. I. E. E. standards are submitted to A. S. A. (the successor of A. E. S. C.) and sectional committees are formed, the revision of such American standards pass automatically from the A. I. E. E. Standards Committee to the Sectional Committees of A. S. A. Gradually, then, standards work in established fields is passing to the committees established by A. S. A. procedure. In new fields, the present confusion will continue in spite of anything A. S. A. can be expected to do.

The increase in number of American associations interested in standard work has also complicated the work of the U. S. Committee of the I. E. C. The relations between this international standards body and A. S. A. has also presented difficulties of an organization nature. With so many associations having a voice, how can the U. S. Committee of the I. E. C. determine the American position on any question? This situation has been very humiliating to American delegates to I. E. C. meetings and American influence and interests have suffered.

The broad purpose of this movement, which the Institute has endorsed, is to unify standards effort in the electrical field, nationally and internationally. The Directors believe there exists an opportunity for the Institute to again serve the industry and the profession by contributing the experience and the facilities of the Institute to this cooperative effort. If this movement succeeds, both the industry and the Institute will benefit.

Harold B. Smith

President.

Abridgment of

Telephone Interference from A-C Generators Feeding Directly on Line with Neutral Grounded

BY J. J. SMITH*

Associaie, A. I. E. E.

Synopsis.—*The problem of telephone interference from a-c. generators, feeding directly on the line with neutral grounded, is discussed. It is shown that the triple and non-triple harmonics in the voltage wave shape cause currents which flow in different paths on the power system. As a result of this, the induction on paralleling telephone lines per ampere of triple harmonic is greater than the induction per ampere for a non-triple harmonic on a balanced power system.*

A method of measurement which would allow a rough comparison of the effects to be expected from both types of harmonics is suggested. This is based upon using the apparatus already available and setting up special connections for test. Data are given showing the results of such measurements made in the factory on a number of machines while they were being tested.

Analyses are given of the wave shape of machines which gave rise to cases of interference. References are given to some of the data already published on methods which have been applied to relieve such situations.

General

DURING recent years, there have been several cases of telephone interference arising from generators which feed directly on transmission systems and have their neutrals grounded. In these cases, if the neutral ground is removed from the generator, the interference as a general rule disappears. Many times it occurs that the system can be grounded through another generator in the same station, and no telephone interference is experienced. In cases where the latter situation has arisen, the power company engineers are liable to regard the machine which gives trouble and which is generally the new machine, as one of poor wave shape. Investigation in a number of cases has shown, however, that usually the harmonics in both machines have been small and of the same magnitude. The difference between the machines lies, however, in the frequency of the harmonics which are present and in their behavior with respect to the paths through which the harmonic currents flow out on the line and return to the generator.

This type of interference has also been experienced on systems where the generator is connected to the line through Y-Y transformers, the neutral of the transformer on the primary side being connected to the neutral of the generator, which may or may not be grounded. The neutral of the transformer on the secondary side is grounded. In this case, the percentage harmonics from line to neutral on the secondary side of the transformer are approximately the same as the percentage harmonics in the line-to-neutral of the generator. The causes and remedies of this type of interference are exactly the same as interference in cases where the generator feeds directly on the line with neutral grounded and will, therefore, not be discussed separately.

In the design of rotating electrical apparatus, an effort is made to keep the harmonics as low as possible, but because it is not practicable to obtain a sine wave distribution of magnetic flux, and since the slots introduced irregularities, harmonics, though they may be small, are always present in the voltage wave of power systems. With perfectly balanced and transposed power systems, or perfectly balanced and transposed communication systems, there would be no interference with the communication circuits under normal operating conditions of the power circuit. Due to the fact that in actual practise perfect balance cannot be attained, the longitudinal voltages,—that is, the voltages to ground, induced on the telephone line by the power circuit,—will act upon the unbalances in the telephone circuit to produce noise currents. In general, when either the power system or telephone system uses the ground as part of the circuit, the effects of the mutual coupling are greater than when both circuits are wholly metallic. As will be shown by an example later, when the ground is used as part of either circuit, the mutual inductance between the circuits is larger than that between metallic circuits, and in addition, grounded circuits cannot be transposed.

Difference between Triple and Non-Triple Harmonics

The harmonics produced by a generator in its phase-to-neutral voltage can be divided into two classes which are essentially different in respect to their behavior on the transmission line. One class is the odd harmonics which are multiples of 3; *i. e.*, the 3rd, 9th, 15th, 21st, etc. We shall call these the triple harmonics. The other, the odd harmonics which are not multiples of 3—*i. e.*, the 5th, 7th, 11th, 13th, 17th, 19th, 23rd, etc.,—we shall call the non-triple harmonics.

The complete paper contains a discussion of the triple and non-triple harmonics on balanced three-phase systems, and as already demonstrated in other papers, shows that,

---

*Electrical Engineer, General Electric Co., Schenectady, N. Y.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., January 27-31, 1930. Complete copy upon request.

(1) On a balanced* three-phase system, no triple harmonics can exist in the voltage between lines, since these harmonics are equal and opposite in each line to neutral leg, and therefore cancel out,

(2) On a balanced three-phase system, no triple harmonic currents can flow in the lines unless some other path besides the system conductors is provided for their return flow. This is because the triple harmonics in each line are in phase and add up at any instant to three times the triple harmonic in any one line. The instantaneous sum of the non-triple harmonic currents, however, at any instant on the three lines is zero.

If a generator is connected to a Y-Y transformer and the neutral of the generator connected to the transformer, it is evident that the triple-harmonic voltage existing between line and neutral of the generator will also exist between line and neutral on the primary side of the transformer, and hence, on the secondary side of the transformer. Thus, the behavior of the harmonics when the neutral of such a transformer is grounded on the secondary side will be the same (except for changes in magnitude of voltage and current due to transformer ratio and effects of transformer magnetizing currents) as if the generator fed directly on the line.

Path of Flow for Different Kinds of Harmonics

When the neutral of a generator is grounded, the triple harmonic in each leg of the generator exists between line and ground, and since the triple harmonics between each line and ground are in phase, we have, for these harmonics, the equivalent of a single-phase generator feeding out on the three lines in parallel, the path for the return flow being through the capacities of the three lines to ground or through any connected equipment with grounded neutral, and then back through the neutral of the generator. It is evident that since the ground return is one side of the circuit for these triple harmonics, transpositions in the power line will make no reduction in the induced voltage in a neighboring telephone line.

For the non-triple harmonics, since the instantaneous sum of the voltages in the three wires is equal to zero, the amount of current which tends to return through the ground is very much smaller than that which flows when the harmonic is one of the triple series, as is shown by a numerical example in the complete paper. If the wires of the three phases were infinitely close together, no harmonic current of the non-triple series would tend to return through the ground. Due to the fact that the the wires are spaced some distance apart, a small amount of such current does flow; but this will not be considered further here, as the considerations applying to it are not the same as those under discussion in this paper.

*Due to the fact that perfect balance cannot be obtained in practise and also since some slight impedance irregularity must exist in actual systems, triple harmonics will usually be found in measurements of line-to-line voltage.

Mutual Inductance for Grounded and Non-Grounded Circuits

Since the paths of flow of the triple and non-triple harmonics are, in general, different, in order to determine the voltage induced on a neighboring telephone line per ampere of harmonic current in the power line, it is necessary to obtain the mutual inductance between circuits which only involve currents in the conductors of the power line, and also currents which flow out on the power lines in parallel and return through the ground.

In an example worked out in the complete paper, it is shown for a particular case which was assumed for the purpose of illustration, that the voltage induced in a parallel wire by a current i flowing out over the three wires in parallel and back through the earth is approximately 40 times as large as that produced by the same current i flowing out through one of the wires and back through the other wires in three-phase relation; and it is this large ratio between the mutual inductance for metallic return currents and earth return currents which makes the effect of the triple series of harmonics returning through the earth considerably more important in considering inductive effects in telephone circuits than the effects produced by the non-triple harmonic currents.

Relation of the Frequency of Harmonics to Their Interfering Effect on Telephone Circuits

A curve showing the relation between the interfering effect of harmonics and their frequency has been obtained experimentally and the results obtained are given in a Review of the Work of the Subcommittee on Wave Shape Standard of the Standards Committee of the A. I. E. E., H. S. Osborne, Trans. A. I. E. E., 38, 1919, p. 261. This Committee developed a network called the Telephone Interference Factor Network which weights the various harmonics in proportion to their interfering value obtained experimentally. The Telephone Interference Factor (T. I. F.) of a machine has been defined as the current in microamperes through the meter of this network per volt applied to the network.

If reference is made to Mr. Osborne's paper, it will be noted that one of the assumptions made in deriving the Telephone Interference Factor is as follows:

"a. The current induced in telephone circuits by a given voltage or current in the power circuit is approximately proportional to the frequency." (*loc. cit.* p. 268).

This assumption was actually put into practise by multiplying the interfering effects per ampere of current in the receiver, obtained experimentally by a factor proportional to the frequency, which was equivalent to making the assumption that the mutual inductance between the power circuit and the telephone circuit was the same for all harmonics irrespective of their frequency.

We have seen, however, in the simple example referred to above that the coefficient of mutual inductance for the triple harmonics which flow through the ground was approximately 40 times the coefficient of mutual induction for the non-triple harmonics. We are presented, therefore, with the problem somewhat as follows: To revise the curve given in Mr. Osborne's paper by multiplying the interfering effect of the triple harmonics by some figure which we shall call T (40 in the above example), at the same time leaving the non-triple harmonics as at present. It would appear to be out of the question to design a network similar to the one already designed, first, on account of the great complexity necessary for a network which would have such irregular impedance characteristics, and secondly, because even if such a network were designed for, say, a fundamental of 60 cycles, it could not be used at 50 cycles since the triple harmonics are of different frequency.

By using special methods for testing on three-phase systems, it would appear that a method can be developed for determining the T. I. F. of a machine using the extra weighting for the triple harmonics. It has already been seen that if the voltages in the three phases of a machine connected delta with one corner open are added, the instantaneous sum of the fundamental and of the non-triple harmonics is negligibly small. The sum of the triple harmonics, however, is three times the amount of harmonic in any phase. Thus, if a machine is connected delta, the voltage measured across the open corner of the delta is three times the voltage of the triple harmonics in each phase. If the T. I. F. of the voltage across the open delta is measured and multiplied by one-third of the voltage across the open delta, this gives the contribution to the current in the T. I. F. network meter due to the triple harmonics in a single phase. If this contribution is multiplied by a factor T and added according to the square root of the sum of the squares to the current in the meter in the network produced when the T. I. F. meter is connected between line and neutral, the resultant divided by the line-to-neutral volts will be a T. I. F. in which the triple harmonics are weighted approximately T times as heavily as the non-triple harmonics.

As an example of the application of the above, we may consider the following measurements on a four-pole 37,500-kv-a. 11,500-volt 60-cycle generator:

Line-to-line	11,500 volts	10 T. I. F.
Line-to-neutral . .	6,800 volts	15 T. I. F.
Open-delta	245 volts	800 T. I. F.

Applying the method given above, the following triple harmonic weighted T. I. F. is obtained (assuming a value 40 for T).

$$\frac{1}{6800}\sqrt{(6800 \times 15)^2 + \left(\frac{40}{3} \times 245 \times 800\right)^2} = 390$$

It may be well to point out that in this method of analysis, the T. I. F. is referred back to the operating voltage of the generator. Sometimes attempts are made to consider the T. I. F. of the open-delta voltage alone; as, for instance it is sometimes stated that the T. I. F. of the neutral current is so much,—say 2000.* It is necessary to remember that the effect of the power system on the telephone system is measured by the product of the voltage (or current), and the T. I. F. There are additional factors such as the length of exposure, separation between lines, etc. In the above example the open-delta voltage of 245 volts is largely composed of third harmonic but the main contribution to the T. I. F. of 800 is made by the higher harmonic. It is, therefore, evident that if the third harmonic were halved, having a value of 122.5 volts, the other harmonics remaining the same magnitude, the T. I. F. of the open-delta voltage would be doubled, giving 1600. In spite of this increase in T. I. F. of two to one, the interference which might be created by these two different machines in any given location would be changed by a much smaller ratio and in some cases would remain approximately unchanged. The weighted triple-harmonic voltage T. I. F. would be the same for these two machines.

For some time past the General Electric Company has been accumulating data on the voltage and T. I. F. measured across the opened corner of machines connected delta when these are designed so that they have the neutral brought out. A table giving typical results which have been obtained is given in the complete paper. In all these machines, the T. I. F. of the line-to-line and normal T. I. F. of the line-to-neutral voltage are very low. In view of the above it is of interest to examine the actual amount of each harmonic present in cases which have given rise to telephone interference.

Analyses of Voltage Wave of Generators in Typical Cases of Interference

Analyses are given in the complete paper of the line-to-neutral voltage both at no-load and under load generators which have given rise to this type of trouble. In one typical case, the harmonics whose magnitude was the greatest in the generator wave shape, the 25th and 29th, did not give rise to noticeable noise on the paralleling telephone circuits. The neutral current of the generator was mainly composed of triple harmonics which were all of the same order of magnitude. The prominent harmonics on the telephone circuit were the 15th and 27th and the elimination of either of these by means of a wave trap reduced the noise considerably.

It will be noticed that in analyses given of line-to-neutral voltage both at no-load and under load, the magnitude of the triple harmonic series was in general

*See for example *Power Distribution and Telephone Circuits*, H. M. Trueblood and D. I. Cone, Trans. A. I. E. E., XLIV, 1925, p. 1058.

equal to, or less than, that found in the best commercial practise in machine design. A study of the magnitude of these harmonics seems to show that none of the ordinary methods open to a designer could be used to reduce these harmonics with certainty to much smaller values. If telephone noise is caused by such a machine, the question of using means for grounding external to the machine should be considered, and whether general conditions will warrant radical modifications in machine design as opposed to other methods of wave correction external to the machine.

Methods Which Have Been Used to Minimize This Type of Interference

In the complete paper, references are given to articles already published describing various methods which have been used to relieve such situations. Some of the methods described apply to generators already installed and which are found to give rise to interference; others refer to certain points which, if given advance consideration, may avoid later modifications if trouble should develop.

Conclusions

The difference in behavior of the triple harmonics and non-triple harmonics has been illustrated, and it has been pointed out how relatively small amounts of triple harmonic voltage existing from line-to-neutral may give rise to more noise on paralleling telephone circuits than considerably larger amounts of non-triple harmonic voltages.

A method has been suggested by which separate measurements can be made of the triple harmonics alone, by a special connection of the machine for test. These measurements can be combined, if desired, under certain assumptions which have been given, with the measurements made in the usual way so as to give an extra weighting to the triple harmonic series which would correspond to their greater inductive effect due to the fact that they return through the earth connection.

A number of references to methods which have been used to minimize this type of interference have been given. Some of these are applicable directly to the design of the generator and others involve auxiliary apparatus for the reduction of the harmonics. A little advance consideration of the subject of this paper may sometimes avoid later modifications if trouble develops.

Although the majority of systems in this country at the present time are operating with grounded neutral, the actual cases of this type of telephone interference are relatively few. Many generators, of course, are connected to transmission lines through delta-Y transformers which greatly reduced the possibility of interference due to the triple harmonics. The cases which have occurred have been serious enough, however, to create a real problem.

There are so many factors involved,—such as the type of power system, proximity to and length of parallels with telephone circuits, capacitance to ground of power conductors beyond parallel, etc.,—that it would be extremely difficult to predict beforehand in any given location whether or not this type of telephone interference will arise. In some cases in which a machine gave rise to telephone interference on one system, it has been found that a duplicate machine operated for years in another location without giving any trouble. This type of interference has occurred more frequently in the last few years, although for many years, it has been common practise to ground systems and although the wave shape of these large turbo alternators has been gradually improved. It can be thus seen that the problem is quite complicated and worthy of study by operating as well as designing engineers.

BUILDING WITHOUT WINDOWS

Experiments are being conducted, according to George F. Paul of Chicago, to determine whether some better method than windows can be devised to utilize natural sunlight for the interior of buildings. There has been established in Chicago a windowless experimental laboratory. This laboratory is flooded with sunlight and sky shine by means of small bull's-eyes that are located along the outer wall and near the ceiling to replace the usual windows.

Dr. Frank E. Hartman, noted Chicago physicist, has designed this unique laboratory. He declares that windows are wasteful of heat, that they distract the attention of workers in offices, that they are inefficient for ventilation, and that they are a costly part of any structure.

"Few schoolrooms and practically no large offices and workshops can be uniformly illuminated by windows," declares Dr. Hartman. He says that much of the complaint of improper heating in winter is due to the disturbing influence of glass, and that it is difficult to locate direct radiation effectively when large glass surfaces are encountered.

The window is, after all, more a necessity of custom than of fact, according to Dr. Hartman. He calls attention to the fact that they are located in vertical walls and that during most of the day they receive only diffused or reflected light. Furthermore, due to the width of the streets and the height of buildings, only the topmost windows derive any advantage from the sun during the morning and afternoon periods.

Another disadvantage that Dr. Hartman finds is that most window glass shuts out the sun's ultra-violet rays. . . . . The ordinary street offers no reflecting surfaces suitable for directing sky shine into windows. On the contrary, it offers surfaces of tremendous absorbing power, with the result that practically no sky shine enters windows.

Dr. Hartman says finally that he believes that the sky shine can best be made available indoors by the use of a series of metallic concentrators, condensers, and reflectors.—*Professional Engineer.*

Abridgment of

Increased Voltages for Synchronous Machines

BY C. M. LAFFOON[1]

Associate, A. I. E. E.

Synopsis.—The appreciable increase in the rating of generators, generating stations, and interconnected systems has resulted in large currents to be handled by generators, circuit breakers, reactors, cables, and station bus structures. This paper covers a discussion of the limitations on large generators and generating equipment by the present standard voltages of generation, the necessity for increasing the values of generated voltage, and the design, manufacturing, and operating problems involved in building high-voltage turbine generators.

* * * * *

AT the present time serious consideration is being given to increasing materially the generated voltages of steam-turbine generators. Generators of higher output are being required to meet the needs of growing loads. The increased currents which must be handled have imposed heavy duties on equipment such as circuit breakers, switches, cables, reactors, and other auxiliary apparatus. On account of the limitations of such equipment and the growing cost and complication of handling heavy currents, it is thought desirable to increase the generator voltage which will allow a corresponding decrease in current.

It is the purpose of this paper to discuss the effect of increased generated voltage on the manufacture, cost, performance, dimensions, and reliability of large turbo generators. The paper is not intended to cover other phases of the matter such as reduced central station cost or decreased losses. These things must be determined for each particular station or power system on the basis of cost, performance, reliability, and life of the combined generating and distributing equipment.

Problems Involved in the Manufacture of High-Voltage Generator Windings

Type of Insulation. The most important problem involved in the design and construction of high-voltage rotating machines is the insulation of the stator windings. A satisfactory insulation material for use on the strands, conductors, and coils of high-voltage windings should conform to the following specification requirements:

1. High breakdown strength when subjected to voltage.
2. Low dielectric losses at normal operating voltages and at test voltages.
3. High resistance to corona and static discharges.
4. Non-hygroscopic.
5. Relatively high thermal conductivity so that the stator copper losses can be dissipated with a minimum temperature drop through the insulation.
6. Sufficient mechanical strength and flexibility for applying it to the strands, conductors, and coils in a satisfactory manner.
7. Resistance to vibration and movement.

Mica is the only material available at the present time which approaches all of these desired characteristics. Its most serious limitation is that it is available only in small sheets or flakes, and does not have high mechanical strength. In order to put mica in such shape that it can be applied to conductors as insulation, it is necessay to apply it to a paper or cloth base to give sufficient mechanical strength. The desired degree of flexibility is obtained by using relatively thin flakes and building up layers of overlapping flakes, together with a satisfactory bonding material. The characteristics of the bonding material should correspond to the desirable characteristics of the insulating material. It is especially essential that the amount of bond and its vapor pressure be low, so that gases will not be liberated when subjected to heat and cause looseness in the insulation layers, and swelling or bulging of the insulation at the unsupported sections. The built-up insulation can be made in the form of tape or wide sheets, and applied to the coils in these forms.

Application of Insulation to High-Voltage Stator Coils. In building coils for high-voltage generator windings, the individual strands and conductors of multiple turn coils are insulated throughout the entire length with mica tape. The company with which the writer is affiliated uses micarta folium wrappers for the straight part of the coil sides. The end turns, connectors, and leads are insulated with mica tape, treated-cloth tape, or a combination of both kinds of tape. The micarta folium insulation used on the straight portion of the coil has been improved during the past few years by the introduction of a bonding material which has a lower dielectric loss, higher breakdown strength, and greater flexibility than the older type bond. The increased flexibility of the wrapper makes it feasible to use a greater percentage of mica in the micarta folium. The micarta folium wrapper is in one piece with respect to the length of the coil side, and is wrapped on and baked simultaneously by means of an electrically heated automatic wrapping machine. All coils are "steam" pressed on the straight parts after insulating in order to remove the volatile matter and obtain a more compact insulation free from air spaces. The treated tape on the end turns, connectors, etc., is applied by hand. Special attention is given to the design and actual manufacturing operations in making the joint between the two

1. Power Engineering Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Presented at the Great Lakes District Meeting of the A. I. E. E., Chicago, Ill., Dec. 2-4, 1929. Complete copy upon request.

29-156

kinds of insulation, so that it will satisfactorily withstand the voltage stresses which exist under actual operating conditions.

Tests on Insulation for High-Voltage Windings. The use of treated cloth tape on the end turns for the coil insulation is desirable on account of the fact that with its greater mechanical strength than mica tape, it can be applied more tightly, and a more compact insulation obtained. Numerous tests have been conducted to determine whether the end insulation and the joint between the mica folium and the end insulation were satisfactory for high-voltage windings. Coils were insulated on the ends with treated cloth tape and with several grades of mica tape. The mica tape was vacuum treated before being applied to the coils. All tests were made at usual room temperatures. The average value of breakdown voltage for the coils insulated with mica tape for 13,200-volt normal operation was approximately 75 kv. and for the coils with an equal thickness of treated cloth insulation, the breakdown voltage was 100 kv. Mica tape for 22,000-volt operation failed at an average value of approximately 100 kv., whereas coils insulated with an equal thickness of treated cloth withstood approximately 140 kv. The voltage was applied momentarily in all cases. All of the test results indicated that treated cloth tape is more satisfactory for insulating the end windings than mica tape and that 25 to 50 per cent greater test voltage can be withstood. The test results indicate that mica tape is also a satisfactory insulation for the end turns and other related parts.

A test bar approximately 8 ft. long was made to represent a section of a stator coil for a large capacity 22,000-volt turbine generator. The bar was insulated with micarta folium suitable for 22,000-volt service, and the ends were covered with micarta tubes in order to obtain sufficient creepage for testing at high voltages. The joints between the micarta folium insulation on the bar and the micarta tubes were sealed with treated cloth tape. The bar was tested at 65 kv. for one minute and did not fail. The test voltage was then raised to 100 kv. and held for 30 seconds and no failure occurred. In making the test, the tin-foil grounding sheath was extended out over the joint, whereas in an actual generator, a long creepage distance is provided from the joint to ground. Built-up sections with 22,000 volt micarta folium insulation have been tested at 175 to 200 kv. momentarily without failure.

Insulation Tests. It is necessary, in the construction of higher voltage generators, to increase the magnitude of the voltage for the insulation tests at the different stages of the manufacturing operations, and the difficulties involved in making the insulation tests increase very rapidly as the test voltages are increased. In view of the fact that the dielectric losses increase very fast for high voltages, it is felt advisable to consider the necessity for maintaining the test voltages for appreciable lengths of time. With the prolonged high-voltage test, the insulation heating due to dielectric losses and surface creepage may become so great that injury to the insulation will result, and the test actually produce more harm than good. It is believed that the present standardized final test voltages of twice normal plus 1000 for one minute can be satisfactorily met for 22,000-volt machines. However, for final test voltages in excess of 50 kv., the length of test should be materially reduced. A shorter time of voltage application should be satisfactory to locate any defects in the insulation, and would be considerably less liable to injure the insulation by excessive heating. If desired, two or more tests of shorter duration could be made with sufficient time interval between tests to permit the insulation to cool.

Shape of Conductors and Voltage Gradient. In designing the conductors of high-voltage windings, special consideration must be given to the shape of the conductors in order to limit the potential stresses at different sections of the insulation. It is not only necessary that the average voltage per unit thickness of insulating material be kept within the safe working range, but stress concentration due to sharp corners and edges must be avoided. The circular conductor is the ideal shape from the standpoint of minimum stress concentration. For a given total voltage to ground, the series concentric cylindrical conductor arrangement is the ideal arrangement from the standpoint of minimum potential gradients.

With the American type of construction in which it is considered necessary and essential that the coils be placed in open slots, it naturally follows that the conductors are rectangular in shape. If standard rectangular copper sections were used for the strands, the built-up conductor and coil would have relatively sharp corners, and there would be stress concentration at these points. The electric field for a conductor with square corners is shown in Fig. 5. In this particular case, the field would be as shown in Fig. 6, if the corners of the coils were provided with a radius equal to one-quarter of the copper width. Since the present practise is to transpose strands of the conductor in the buried part of the coil, it becomes a difficult and expensive proposition to put the necessary radii on the respective strands by hand. In this connection, it is felt that a half-round strip or strip with well-rounded corners, should be placed at the top and bottom edges of the top and bottom coils respectively. This strip would be insulated from all of the strands except possibly one and provided with the usual amount of strand insulation. This strand would assume the potential of the conductor to which it is applied, and would aid materially in reducing the stress concentration at the corners as shown in Fig. 7. In all of these cases, the outside surface of the coil is provided with an asbestos tape covering which is filled with a high-resistance grounding compound. The electrostatic fields are based on the outside surface of the coil being at ground potential. As a further means of reducing the concen-

tration of stress on different parts of the insulation, it is proposed that equipotential surfaces be provided at different intervals in the insulation. The wrappers can be applied in approximately three parts, and conducting films can be located at the corners of the coil over restricted sections, and thus establishes definite potential surfaces. The type of conducting material and its arrangement can be controlled so that no resistance

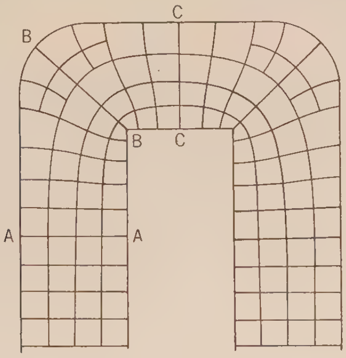

FIG. 5A—ELECTROSTATIC FIELD

Rectangular conductor with square corners. (33,000-volt insulation)

losses of appreciable magnitude are introduced due to circulating currents. The magnitude and distribution of the electrostatic field are shown in Fig. 8.

EFFECT OF INCREASED VOLTAGES ON GENERATOR COST, WEIGHT, AND PERFORMANCE

In extending the design of any apparatus into unknown regions, there is a forced necessity for basing engineering judgment and conclusions on past experi-

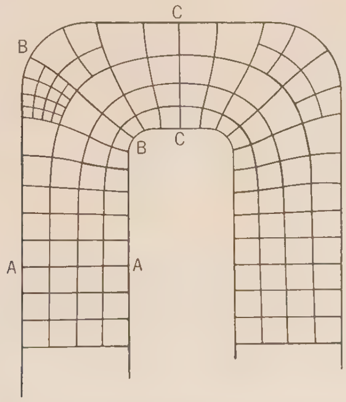

FIG. 6A—ELECTROSTATIC FIELD

Rectangular conductor with round corners. (33,000-volt insulation)

ences, and present available information. There are insufficient data available at the present time to determine the best thickness of the insulation for the higher voltage generator windings. With a given type of insulation, the optimum thickness of insulation must be based on a compromise between the average volts per inch of insulation and the total thermal drop through the insulation due to the stator winding copper loss.

The data in Table II have been arranged to show the total space required for micarta folium insulation for different voltages and slot combinations on four-pole, 1800-rev. per min., 60-cycle turbine generators.

With the increased thickness of insulation on the coils for high-voltage windings, it is necessary to work the stator copper at a lower current density on account of the higher thermal drop through the insulation. This

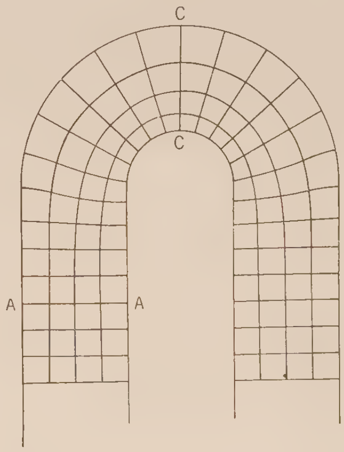

FIG. 7A—ELECTROSTATIC FIELD

Rectangular conductor with half round strip on top. (33,000-volt insulation)

means that a greater percentage of the stator periphery is required for the stator copper than for lower voltage machines. With the greater space required for insulation and stator copper, it is necessary to increase the length of the stator core in order to keep the magnetizing

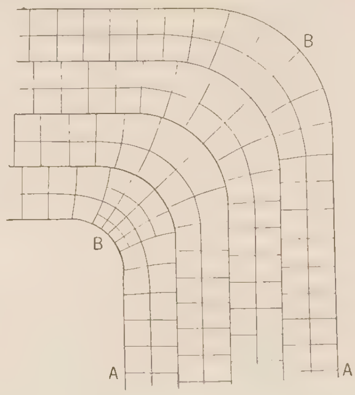

FIG. 8A—ELECTROSTATIC FIELD

Rectangular conductor with round corners. Three conducting films equally spaced in insulation, completely surrounding conductor. (33,000-volt insulation)

flux density in the teeth within a range of safe working values. If the rating and voltage are such that a larger number of stator slots is required, the length of the machine will have to be increased further, on account of the additional insulation requirements. Preliminary studies and estimated costs indicate that the manufacturing cost of a 22,000-volt turbine generator of relatively large capacity would be approximately 20 to 25

per cent more than that of a generator of the same rating wound for a suitable lower voltage. Similarly, the increase in cost for a 33,000-volt generator would be on the order of 40 to 50 per cent. There would be a corresponding increase in the weight and dimensions of generators when built for high-voltage service.

Summary and Conclusions

At the present time, there is a definite need for materially increasing the generated voltage of large stream-turbine generators due primarily to the limitations in the current-carrying capacity of the oil-filled type of circuit breakers and to the increased cost of switches, reactors, and cables for the relatively high current values at present standard voltages. Based on the results of tests and research development, and on the operating experience with several 18,000-volt synchronous condensers and 11,000-volt single-phase turbine generators which are provided with 19,000-volt insulation and operate with one terminal grounded, it is felt that turbine generators wound for voltages between 16,500 and 25,000 volts should give satisfactory operation, provided adequate judgment and precautions are followed in their operation. It would not be recommended that a high-voltage generator be connected directly to a transmission line or distribution system unless the existing conditions were such that the windings would not be subjected to potential surges of dangerous magnitude. The cost of a 22,000-volt turbine generator will be 20 to 25 per cent more than for a similarly rated machine of suitable lower voltage. In the case of large capacity units, the increase in cost and reduction in efficiency of performance will probably be more than offset by the reduction in cost of step-up transformers, cables, and bus bars.

In the case of 33,000-volt machines, there is no operating experience available for such voltages; consequently, it will be necessary to complete a comprehensive program of research development and obtain reliable operating data on 22,000-volt generators before concluding that it is feasible to build satisfactory 33,000-volt generators. As the situation now stands, the building of a 33,000-volt machine of relatively large capacity and great importance should be undertaken jointly by the manufacturer and purchaser, as a development proposition.

Abridgment of

The Conductivity of Insulating Oils

BY J. B. WHITEHEAD* and R. H. MARVIN*

Fellow, A. I. E. E. Member, A. I. E. E.

Synopsis.—*The paper describes experiments on the charging current and other associated phenomena in high-grade transformer oil. The charging currents remaining after the elimination of the initial transient were studied to within a few hundredths of a second of application of continuous voltage. Two samples of the same oil obtained at different times differed radically. In one case the charging current fell off from the start, while in the other, it remained constant for an appreciable time or even temporarily increased. On reversal of polarity after a long charge, the initial current with both specimens was the same as before reversal, but with one a large momentary increase occurred a few seconds later. Evidence is given on the time of recovery of the initial condition. The existence of space charges in the charged oil is shown, and the time of formation of these charges together with the resulting non-uniform distribution of voltage is measured. Since it is the initial conductivity which determines the a-c. loss, the importance of the charging current in its early stages is emphasized.*

* * * * *

Introduction

In this paper, we present the results of a series of studies on the initial, or short-interval conductivity of high grade insulating oil. New evidence is presented as to the properties of the ions involved, the peculiarities of the resulting electric conduction, the wide variations of the latter with slight change of conditions, and other matters having apparent bearing on the behavior and life of the oil as an insulator.

Experimental Methods

In the present work, the principal observations were those of the charge and discharge currents under continuous voltage. The photographic records begin within a small fraction of a second after the application of voltage or short circuit. An Einthoven string galvanometer was used in conjunction with a rapid charging, short-circuiting, discharging, and reversing switch. Further description of this apparatus is given in an earlier paper.[2]

The oil was placed in an open glass vessel into which were immersed a pair of parallel plates constituting the measuring condenser. The plates were of brass, each of 311 sq. cm. area, and each completely surrounded by a guard ring 3.7 cm. wide in its own plane.

The Oils

Oil (*A*). This was of the highest grade of in-

*Both of The Johns Hopkins University, Baltimore, Md.

1. For numbered references see Bibliography.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930. Complete copy upon request.

sulating oil, furnished by a well-known refinery. Among other data furnished by the manufacturer is the following: "Resistivity 1.8×10^{14} ohms per cu. cm.; moisture content about 0.002 per cent; air content unknown, but approximately saturated."

Oil (B). As a deteriorated oil, a sample of the same oil as Oil (*A*) was taken from a 50-gal. metal drum which had been shipped under the same conditions, but from which oil had been drawn from time to time over a period of several months. Deterioration, if

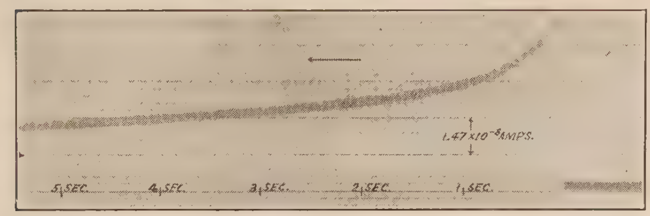

Fig. 1—Oil "A"—Charge at 1500 Volts

Spacing of plates, 0.15 cm.

present, was due solely to such air as had been admitted to the drum during the withdrawals of oil, and to any possible influence of the walls of the drum itself.

Observations on Oil (*A*)

Charging Current Curves. Fig. 1 shows the photographic record of the charging current-time curve when 1500 volts are applied to Oil (*A*), with plate spacing of

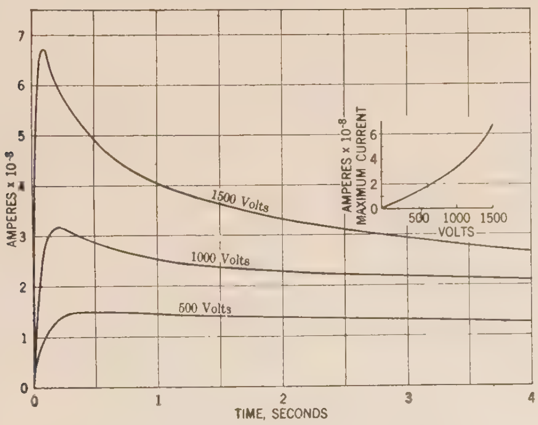

Fig. 2—Oil "A"—Current on Charge

Spacing of plates, 0.15 cm.
Area of plates, 311 sq. cm.

0.15 cm. This curve resembles the typical dielectric absorption curve noticed in solids. It is, however, of brief duration, the current reaching an approximately constant value after three seconds. This curve is reproduced in Fig. 2, together with those on the same specimen taken at 1000 and 500 volts. The curves are not of exactly the same shape, and the initial ordinates increase more rapidly than in proportion to the voltage. The final long time conductivity is independent of voltage in the range studied. We call attention to the probable value of the short interval method for further study of this relationship in its bearing on the approach to breakdown voltage.

Discharge Curves. It is usually assumed that good dielectric liquids show no residual charge. Both the oils studied here are in general accord with this assumption.

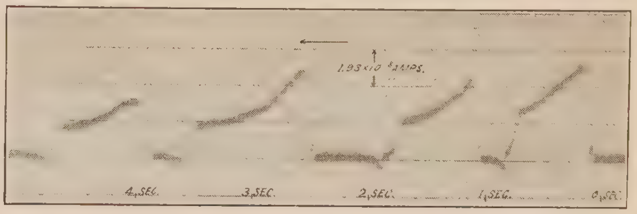

Fig. 3—Oil "A"—Charge with Intervals of Short Circuit

No foregoing charge
1500 volts. Spacing of plates, 0.15 cm

Charge at Reversed Polarity. The pronounced differences between the charge and discharge conditions, above, raise several questions as to the type, permanence, or rate of recovery, and other features of the anomalous conductivity indicated by the charging current. Consequently a series of records was taken in which a period of charge was followed by a reversal of voltage. The sequence of operations was as follows: After a long period of charge, the circuit is opened for 0.005 sec., following which the circuit is closed in the reverse direction. After 0.0025 sec., during which the reversal of geometric charge and circuit transient have disappeared, the string galvanometer is put in circuit. After the short photographic record, the d'Arsonval galvanometer gives the long time current values.

Upon reversal, the initial peak is absent; at 0.2 sec. the current is somewhat, though not much, greater than that immediately before reversal and decays slowly to that value. We interpret this result as indicating an appreciable, though not great, recovery of initial conductivity during the 0.005-sec. interval of open circuit,

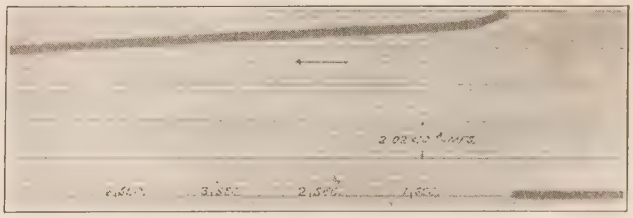

Fig. 5—Oil "B"—Charge at 1500 Volts

Spacing of plates, ¼ cm.

and that on quick reversal of field, the conductivity remains substantially unchanged.

Successive Short-Interval Charges. Further evidence of the time necessary for the recovery after interruption and short circuit is given by the record of Fig. 3, which shows a succession of charging intervals all at the same

voltage and polarity, but with short circuits of varying duration in between, and in Fig. 4, in which we have the same succession of charging intervals, but which are taken after a very long foregoing period of charge. This record shows that the shorter the period of interruption and short circuit, the greater the difference between the foregoing current pulse and that which follows; and conversely, the longer the period of interruption, the nearer the approach to the original condition.

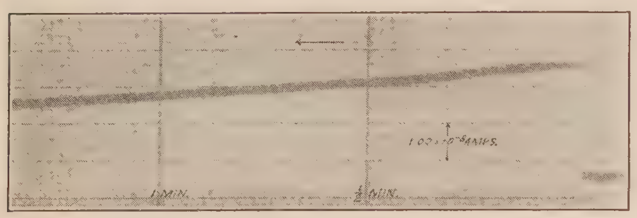

Fig. 6—Oil "B"—Charge at 1500 Volts

Spacing of plates, 1 cm.

To further study the rate of recovery beginning after a long period of idleness, a series of charging curves was taken, each of 15-min. duration, with increasingly long intervals of idleness in between. In this way it was found that about three hours was necsary to restore the oil to its initial condition.

Observations on Oil (*B*)

Charging Current. The charging current time curves of this oil differ markedly from those of Oil (*A*). They are characterized by an initial value which remains approximately constant over a period of two seconds or more. This is indicated by the record of Fig. 5, which should be compared with that of Fig. 1, both being taken under approximately the same conditions. The difference between the two is further emphasized by the long time curve of Oil (*B*) in Fig. 6.

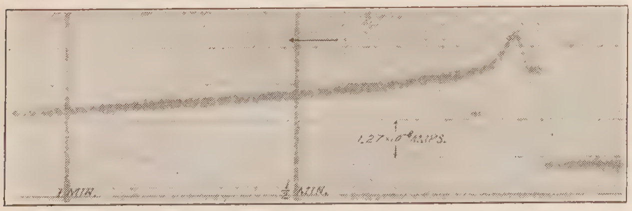

Fig. 7—Oil "B"—Charge at 1500 Volts

Spacing of plates, ½ cm.

At times the initial portion of the charging curve for Oil (*B*) contains a slight hump shortly after the application of voltage. (See Fig. 7.) The appearance of this hump is limited to records taken at the higher values of gradient, and is sometimes entirely absent.

The essential differences between the two oils are: (1) that the initial values of charging current in Oil (*B*) are well in excess of those in Oil (*A*); (2) these initial values in Oil (*B*) are substantially constant over an interval of a second or more while those in Oil (*A*) are falling rapidly from the start; and (3), the initial values in Oil (*B*) are closely proportional to the applied voltage while those in Oil (*A*) increase more rapidly than the voltage.

The outstanding features of all records of this character on Oil (*B*) are as follows: At first the reverse current is approximately constant over a period of perhaps one second and at about the same value as that at the end of the preceding period of charge in the opposite direction. The current then rises rapidly to a maximum, this maximum occurring anywhere from 2.5 to 7 sec. after the reversal. The magnitude of this maximum may be as great as 40 times the initial constant value of current on reversal, and from two to three times the initial value of charging current when voltage is applied to the neutral oil, the ratio increasing with increasing field strength. These peaks in the reverse current are not evident in the lower range of values of field strength. For higher values, the principal peak may be followed by a tendency to a second peak of very low value before the current reaches a final constant value, see Fig. 8.

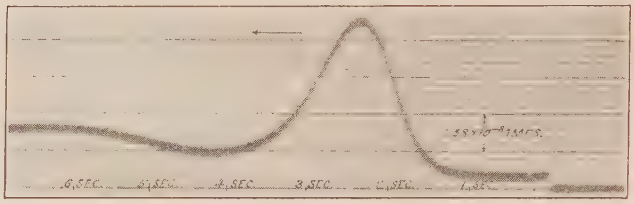

Fig. 8—Oil "B"—Reversal of Polarity at 810 Volts

Spacing of plates, ½ cm.

This reversed polarity curve clearly suggests that the oil possesses two types of conductivity. One of these is quick in response and is seen in the initial and final charging current, in the initial current on reversal, and may therefore be any one of the several types of conductivity which have been suggested for liquids—namely, electrolytic, or perhaps a type analogous to that in gases.[4] The second type of conductivity is that involved in the high peak in the reverse current.

Non-uniform Potential Distribution. If after the application of voltage the oil contains separated space charges of opposite signs and these are distributed through the mass of the oil, they upset the normal uniform potential gradient generally ascribed either to a perfect dielectric or to a uniformly conducting material, and cause a non-uniform potential gradient.

The experimental method is simple in principle, being merely that of measuring the potential acquired by a test electrode or probe placed at different positions between the two charged plate electrodes.

On first application of voltage the potential distribution remains uniform throughout for from 15 to 30

sec. The potential at any point off the central plane, then charges with time, at first rapidly and then arriving more or less abruptly at a final steady value after from 5 to 10 min. This is indicated by the curve of Fig. 9, which thus shows the time rate of change of the potential of plane occupied by the test electrode from its

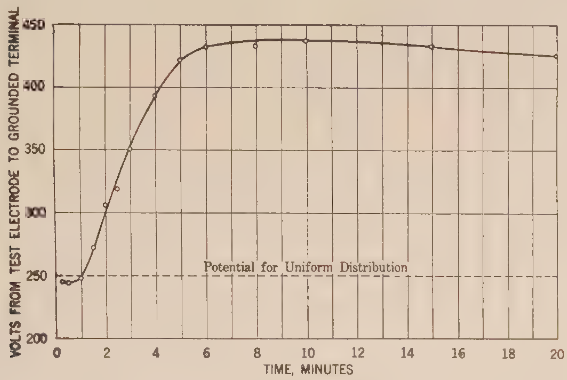

Fig. 9—Oil "B"—Variation of Time of Potential Distribution in Transformer Oil

Area of plates, 311 sq. cm.
Spacing of plates, 2 cm.
1500 volts between plates
Test electrode ½ cm. from grounded terminal

initial value pertaining to a uniform field between the plates.

It is evident from the curve of Fig. 10 that there is a marked variation of potential gradient between plates, that it is symmetrical with reference to the two plates, and that the gradient is greatest towards the two electrodes. The shape of the curve suggests that the potential gradient is steepest near the electrodes. There is an indication, however, of a distributed space charge, rather than a thin layer of high potential difference at the surface of the electrodes, as suggested by Hartshorn,[5] Black,[6] and others. Fig. 11 shows the relation between the time variation of the potential of the test electrode and the resulting total current through the oil.

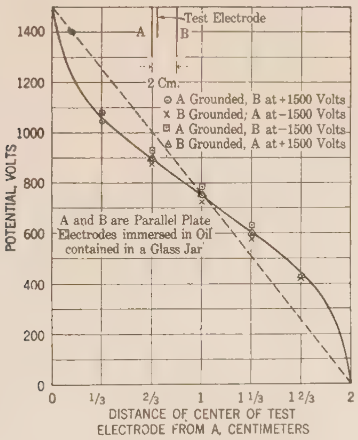

Fig. 10—Oil "B"—Distribution of Potential in Transformer Oil in Study Condition

(After passage of current for 30 min.)

Detection of Space Charge. The presence of a space charge may be directly observed by the following simple experiments: Voltage is applied for some time to a pair of plates immersed in oil, a ballistic galvanometer being connected in series. If the plates are moved suddenly parallel to themselves into a fresh region of oil, the galvanometer gives a negative swing, indicating that the original charge on the plates is greater than that which pertains to the initial application of voltage to fresh oil.

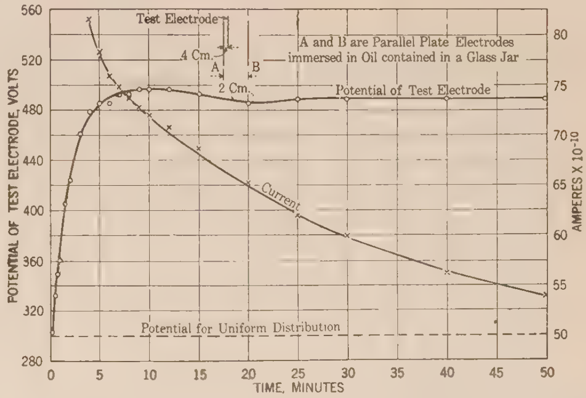

Fig. 11—Oil "B"—Variation with Time of Potential Distribution and Current in Transformer Oil

Area of plates, 311 sq. cm.
1500 volts between plates

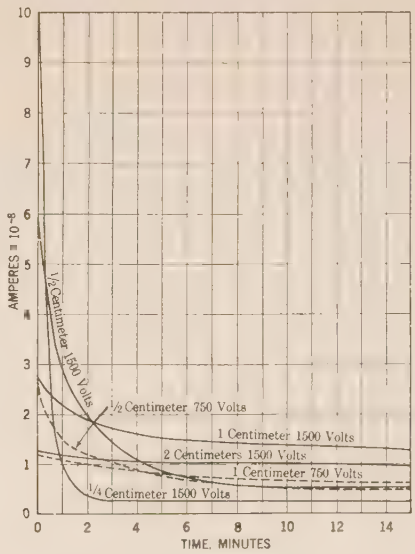

Fig. 12—Oil "B"—Current on Charge at Various Spacings and Voltages

Area of plates, 311 sq. cm.

This can be accounted for only by the increased capacity in the original oil due to the polarizing influence of the space charge. If a pair of neutral plates is moved into the region of stressed oil following the withdrawal of the active electrodes, a gold leaf electrometer connected to the neutral electrodes gives a sharp deflection followed by a slow decrease due to the space charge or polarization of the oil from which the polarizing field has been withdrawn.

The Saturation Currents. In Fig. 12 is found a number of complete charging current time curves on Oil (*B*), the initial values being taken from the string galvanometer records and the later values being read by the galvanometer. The spacings are from 0.25 to 2 cm. and the voltages 750 and 1500 volts. We note two important characteristics of these curves: First the initial value of current which we have already noted remains constant for one second or more (not evident in these curves owing to the extended scale) is shown to be almost exactly proportional to the potential gradient indicating a constant initial conductivity. The value of this conductivity, from the average of 30 records taken over the whole range of spacings and voltages, is 5.1×10^{-14} mho per cu. cm. Of interest also is the fact that a saturation condition is indicated in the values of the final steady current. The readings at 1500 volts show that the final steady current decreases with decreasing spacing below 1-cm. spacing. The comparison of the curves at 750 volts and 1500 volts indicates that with double spacing at the same gradient the current increases. These facts are in general agreement with the saturation phenomenon in gases, although the numerical relationships are not exact.

Energy Loss Under Alternating Stress. The exceptionally high insulating properties of these oils result in very low values of energy loss. However, in using a high sensitivity Wien bridge with three stages of amplification, we have succeeded in measuring the loss at 1500 and 1000 volts, 60 cycles, the resulting values being 1.13×10^{-4} and 0.43×10^{-4} watts. These figures represent power factors in the neighborhood of 0.0003.

The charging current curves under continuous voltage may be expressed in terms of apparent resistance, and the values corresponding to the initial peaks of charging current curves for the conditions under which the above alternating measurements were made are 3.33×10^{10}, 3.13×10^{10}, and 2.24×10^{10} ohms for 500, 1000, and 1500 volts, respectively. If the alternating loss be expressed in terms of parallel connected resistance, the figures given in the foregoing paragraph are 2.4×10^{10} and 2.73×10^{10} ohms for 1500 and 1000 effective alternating voltages, respectively.

These figures indicate that the apparent resistances computed from the charging current curves are of the correct order of magnitude to account for the a-c. loss. In other words, the anomalous conductivity of the liquid is sufficient to account for the loss and it is not necessary to invoke any more obscure causes.

Conclusions and Discussions

The principal results of the work are:

1. Charging current curves of a high-grade insulating oil have been studied to within a few hundredths second of the first application of continuous voltage, over the range 0.25 to 100 volts per mil.

2. Typical dielectric absorption curves are found in some cases. In others striking differences and peculiarities are found. Two orders of the same oil differed radically. The methods gives great promise for the detection of fundamental differences among various samples and materials.

3. Short time discharge studies gave no evidence of residual charge.

4. Under continuous potential the oils show a non-uniform potential gradient. This is found to be due to space charges in the volume of the oil.

5. Long time application of continuous potential improves the oil substantially, but only for a limited time, the oil slowly reverting to its original state.

6. Loss measurements under alternating stress indicate that the anomalous conductivity under continuous stress is sufficient to account for all the loss.

The work has been carried out under the provisions of a grant by the Engineering Societies Research Board to the Johns Hopkins University, the problem being sponsored by the American Institute of Electrical Engineers. Contributions to the fund have been made by a number of industrial corporations. The authors wish to express their appreciation of the constant interest and encouragement of the Engineering Societies Research Board and of the support of the contributing companies.

Bibliography

1. *Handb. d. Physik*, XIII.
2. J. B. Whitehead and R. H. Marvin, A. I. E. E. Trans., Vol. 48, No. 2, April 1929.
3. G. Mie, *Ann. d. Physik*, 26, 1908, p. 597.
4. J. Schröder, *Abb. d. Physik*, 29, 1929, p. 125.
5. L. Hartshorn, *Proc. Phys. Soc.*, 37, 1925, p. 215.
6. D. H. Black, *Phil. Mag.*, 36, 1928, p. 369.
7. J. B. Whitehead, *Franklin Inst. Jl.*, 4, 208, 1929, p. 453.

SOUND WAVES VISIBLE AS LIGHT

By means of a new device, known as the projection osiso, described in the *Transactions* of the Illuminating Engineering Society, it is now possible to see sound waves dance visibly across the screen, exactly as these waves dance across the air to an audience.

The sound waves are caught by a microphone, which can be placed in any convenient location, and are conveyed electrically to an osiso, which consists essentially of a delicately suspended mirror that is oscillated in unison with the received sound waves. A beam of light directed on this mirror, is reflected by it to a system of revolving mirrors, which, in turn, project it upon a screen.

When all is quiet 'round the microphone, a long white line is seen on the screen but as soon as any kind of a sound reaches the sensitive electrical ear, the white line on the screen is thrown into waves, much as a clothes line is thrown into waves when its end is shaken. The form of these waves varies with the sounds producing them, and they range from gentle ripples, produced by low pure tones, to the most intricate of patterns produced by loud complex chords and noises.

The Metal-Clad Switchgear at State Line Station

BY A. M. ROSSMAN*
Fellow, A. I. E. E.

***Synopsis.**—This paper describes a 22-kv. metal-clad outdoor type of switchgear. The design is a new departure from customary engineering practise in that all live parts are immersed in oil and enclosed in metal housings with each phase in its own independent compartment.*

The switchgear insures maximum safety to the operating and maintenance personnel and reduces construction costs for power station switching.

The design is well adapted to mass production which should lead toward standardization resulting in a material savings in cost of manufacturing.

* * * * *

THE State Line Power Station is located on the shore of Lake Michigan just east of, and adjacent to the boundary line between the States of Illinois and Indiana. This boundary line is also the eastern boundary line of the City of Chicago. The station is strategically located to supply electrical energy to the Chicago district, particularly to the industrial section that extends from the center of Chicago to east of Gary. The present plans for the ultimate station call for a generating capacity of 1,400,000 kw.

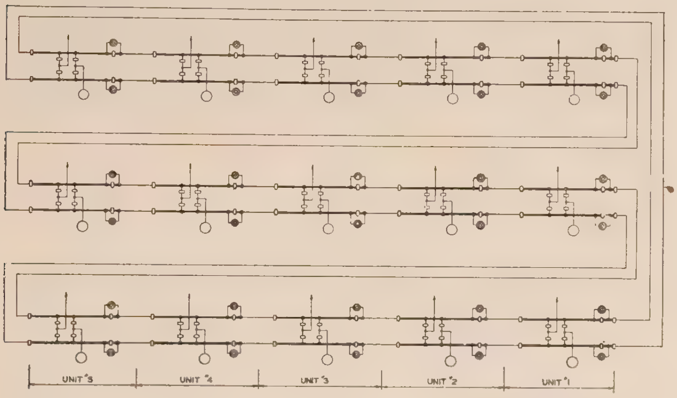

FIG. 1—DIAGRAMMATIC SCHEME OF CONNECTIONS SHOWING MAIN BUS BARS, REACTORS, AND FEEDERS

Reactance of each generator 15 per cent bus reactors 9.2 per cent based on maximum generator rating of 89,411 kw.

The three generators of each unit are connected 120 deg. apart on the ring bus. There is one bus section per generator and the different bus sections are tied together through bus reactors

When a generator is disconnected from the bus bars its corresponding bus reactor is automatically short-circuited so that but one bus reactor is in the circuit between any two adjacent connected generators

The initial installation is a three-machine unit rated 208,000 kw. at 0.85 power factor. It is made up of a high-pressure turbine with generator rated 76,000 kw. at 0.85 power factor or 89,500 kv-a., and two low-pressure turbines with generators each rated 62,000 kw. at 0.85 power factor or 73,000 kv-a., and two, 4000 kw. at 0.7 power factor auxiliary generators, one direct-connected to each low-pressure turbine. In order to keep currents within reasonable limits, the generators were wound for 22,000 volts. At this voltage, the large generator has a rated current of 2350 amperes.

The initial electrical design problem was the development of a system of connections that would handle the ultimate output of the station without excessive concentration of energy under short-circuit conditions and which would also give such a balance of current flow in the bus bars that there would be no undue disturbance of current flow when a machine is connected to or disconnected from the bus bars. The diagram finally adopted is shown in Fig. 1. The diagram is shown in a somewhat different form in Fig. 2. It utilizes a duplicate closed ring bus to which the three generators of a unit are connected 120 deg. apart. Adjacent generators are separated by bus reactors. The short-circuit kv-a. computed for five units (1,000,000 kw. at 0.85 power factor) are shown by the curves of Fig. 3. Attention is called to the fact that with this system of connections there is little increase in short circuit kv-a. after the second unit is installed. The oil circuit breakers have a rated interrupting capacity of 2,000,000 kv-a. By spacing the three generators 120 deg. apart around the ring bus instead of connecting them to adjacent sections, the second objective—a better balance of bus bar currents—is achieved.

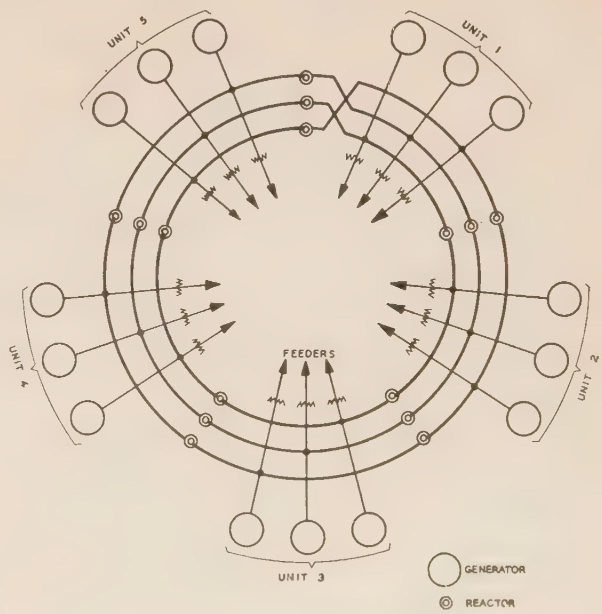

FIG. 2—RING BUS DIAGRAM SHOWING ONLY ONE BUS

The next major problem was to design a suitable bus

*Electrical Engineer, Sargent & Lundy, Chicago, Ill.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930. Printed complete herein.

and switching structure. The conditions that were considered fundamental in this structure were:

1. That the oil circuit breakers be located out of doors.

Fires involving indoor switching equipment frequently fill the switchhouse with conducting gases which threaten and frequently cause secondary short circuits. Also, the dense clouds of heavy black smoke given off by the burning insulation and oil prevent the ready location and isolation of the faulty equipment, and retard the extinguishing of the fire. Experience of many years has shown that fires involving outdoor switching equipment are for the most part less disastrous to the equipment, and are more easily controlled.

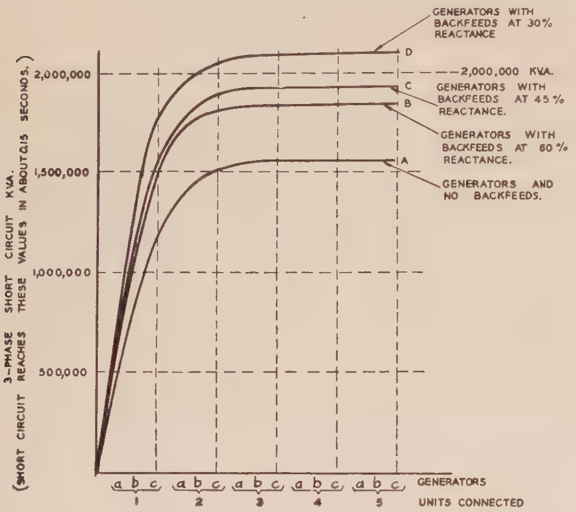

Fig. 3—Short-Circuiting Values for State Line Station

1—Gen. a = 72,900 kv-a.
Gen. b = 89,400 kv-a.
Gen. c = 72,900 kv-a.
Total for 1 unit 235,200 kv-a.
2—Backfeeds on each unit
Gen. a & c = 1-20,000 kv-a. & 1-60,000 kv-a. backfeeds
Gen. b = 2-60,000 kv-a. backfeeds
3—Gen. reactance = 15.5% on all machines
Bus reactance = 9.2% on 90,000 kv-a.

2. That all live parts be enclosed in grounded metal housings, each phase in its own independent compartment.

While metal-clad compound-filled indoor type switchgear has been built for many years, manufacturers of switchgear had not yet developed designs suitable for outdoor service. It was therefore necessary that studies be made to determine the fundamental principles of the design.

First began an investigation of metals to determine which ones had characteristics which made them suitable for enclosures for the large conductors. During this investigation there were gathered together from manufacturers on both sides of the Atlantic a varied collection of plates and tubes of non-magnetic metals. These included manganese steel alloys, nickel chromium steel alloys, copper and copper alloys. The tubes were of ⅛-in. metal approximately 7 in. in diameter. In order to make the different materials comparable on test, the plates were formed from ⅛-in. material to the same diameter as the tubes, and then welded.

Through the courtesy of the Public Service Company of Northern Illinois, which placed at our service the laboratory and personnel of its testing department, a series of thermal tests were run on these tubes. The most important test was one made by looping a conductor through all of the tubes in series and then passing through the conductor 60-cycle currents up to 4000 amperes. This test revealed almost no difference in the temperature rises of the different tubes. This result was contrary to our expectation that eddy currents would cause greater losses and consequently higher temperatures in some of the pipes. It was then decided to use copper, because copper is close grained, is cheaper than the other metals, is easily worked in a well-established industry, and successfully withstands wide changes in climatic and atmospheric conditions.

It was also shown by test that the metal pipes would, if grounded at both ends, set up sheath currents that caused excessive temperatures. Provision was therefore made in the final design for insulating the pipe at one end and grounding it at one place only. A similar precaution was taken against tying together at more than one point, pipes carrying currents of different phases.

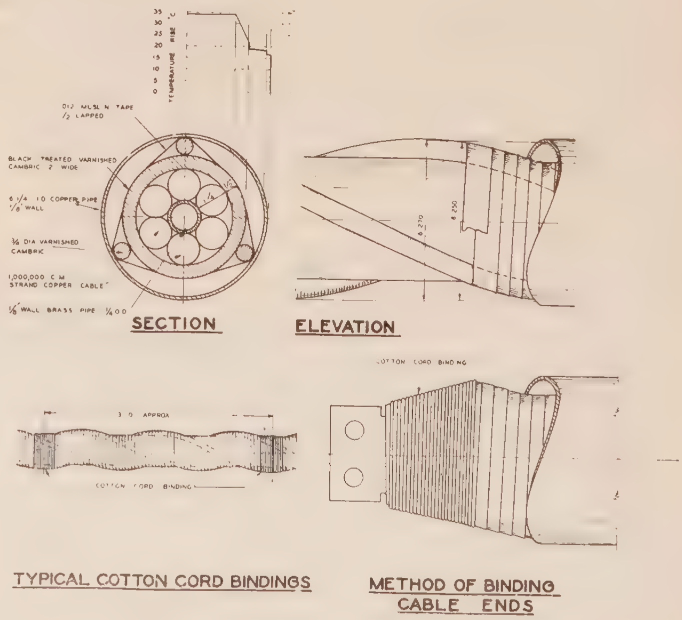

Fig. 4—Conductor and Pipe Enclosure, State Line Station

The next problem was to develop a small diameter conductor of large ampere carrying capacity with small skin effect. The General Electric Company kindly provided shop and laboratory facilities and the cooperation of their engineers to build and test various types of transposed bar and stranded cable conductors. From these tests a satisfactory design was evolved. This consists of six 1,000,000-cir. mil stranded conductors laid around a hollow center core. Each strand is independently insulated. It was found by measure-

ment that the a-c. 60-cycle resistance of this conductor was approximately 125 per cent of the d-c. resistance. (In a sample of the same size with bare strands this ratio was 168 per cent).

Fig. 4 shows a cross-section of the conductor and pipe in the completed assembly. Above this section is

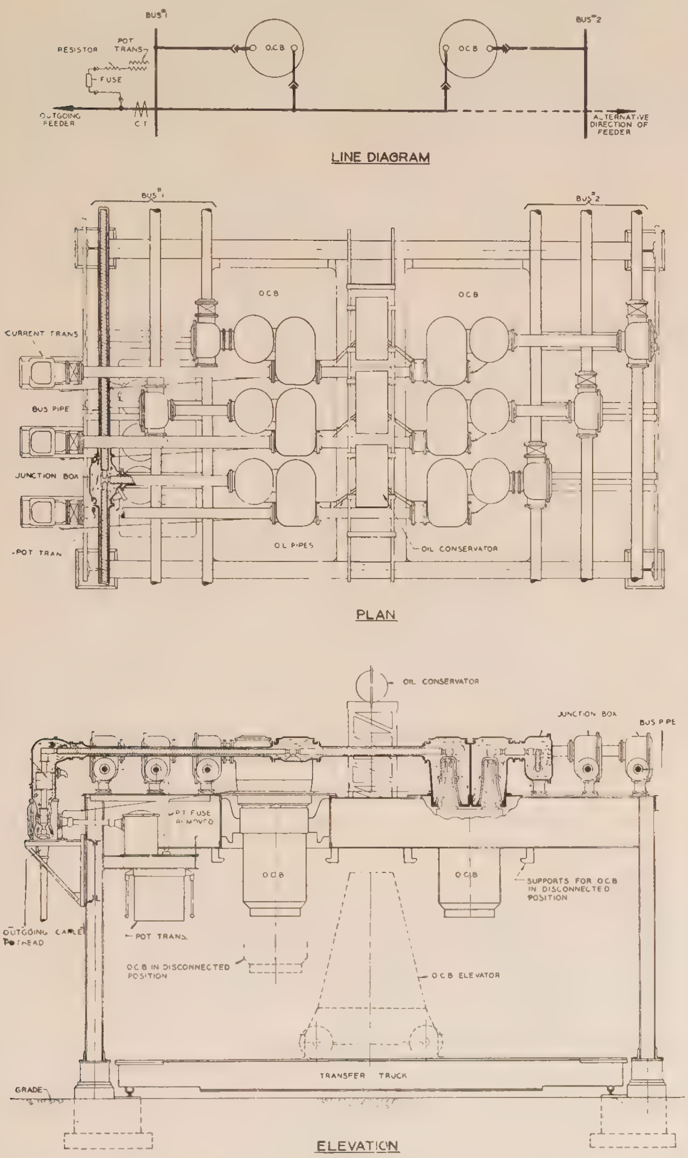

Fig. 5—Metal-Clad Switch Structure—Unit No. 1, State Line Station

shown the temperature distribution from conductor through the various media to the outside air with 2500 amperes at 60 cycles flowing in the conductor. The temperature rise of the conductor is about 30 deg. cent. While the performance of this conductor was satisfactory, it is now being superseded by one less costly to manufacture.

Other details that involved much study, search for materials, and testing, were the junction boxes, expansion fittings for both pipes and conductors, conductor terminals, devices for centering the conductors in the tubes, oil diaphragms, and insulating joints to prevent the flow of circulating currents in the metal enclosures. A description of the various schemes considered, designs worked out, and models made and tested would unduly extend the length of this paper.

A typical circuit bay as built and installed at State Line Station is shown in plan and sectional elevation in Fig. 5. All live parts are covered with a solid insulation. The space between the insulation and the metal enclosure is then filled with mineral oil. This gives an insulation designed to withstand a test of 85 kv. for one minute between the live parts and their metal enclosures. Oil-tight barriers subdivide the oil reservoirs into nine compartments per bay. Oil is piped to these compartments from elevated conservators.

Current transformers are bolted solidly to the conductors and are immersed in the oil which surrounds the conductors.

Circuit breakers and potential transformers are detachable. They are raised and lowered by a portable motor operated elevator. This arrangement permits the elimination of disconnecting switches and very greatly simplifies the interlocking.

A plan of the complete switching structure of 23 bays with the transformers adjacent thereto is shown on Fig. 6. A typical cross-sectional elevation is shown on Fig. 7. Connections between switching structures and

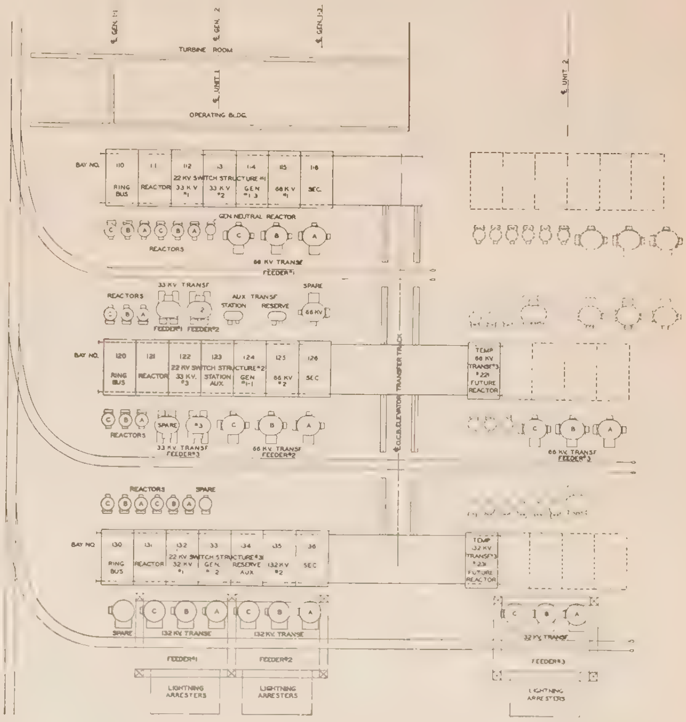

Fig. 6—General Arrangement of 22-Kv. Switchyard—State Line Station

power equipment are made with single-conductor, lead-covered cables through oil-tight cable end bells. The cables are supplied with oil by special independent expansion type oil reservoirs. The end-bells are provided with insulating joints to prevent the flow of circulating currents in the cable sheaths and to prevent the shunting of fault currents to ground through the cable sheaths.

Inasmuch as all live parts are surrounded by metal

enclosures which are in turn mounted on a metal supporting framework, it was only necessary to insulate the supporting framework from ground to make it capable of utilization as a ground fault bus. This was done by inserting insulating blocks in the steel supporting columns and then grounding the upper structure through current transformers. Any fault current must then pass through the current transformers to reach ground. Their secondaries are connected to relays which when they trip cause all the circuit breakers in that section to trip out and thereby isolate the section.

As no live parts are exposed, it is possible for an inexperienced person to climb all over the switching structure without danger of electrocution.

The structure at State Line Station was first energized at 22 kv. on November 20, 1928. It has been delivering energy in commercial service since April 8, 1929.

The State Line equipment was shipped piece by piece, and much of the erection was carried on through the winter months. This method of erection, especially under cold weather conditions, was found to be slower and more costly than had been expected. To improve these conditions, a subsequent study has been directed

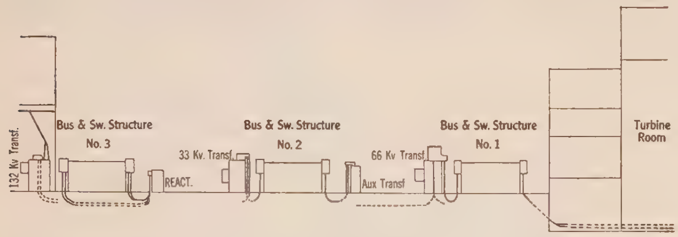

Fig. 7—Sectional Elevation—22-Kv. Switchyard—State Line Station

toward modifying the design so that more of the parts could be assembled in the factory and fewer in the field. This study developed the more compact arrangement of parts shown in Fig. 8. Here, except for the normally detachable parts such as oil circuit breakers, potential transformers, and a few minor parts, all of the housings and all the current carrying parts of each circuit are assembled at the factory into three groups. In the field, these three group assemblies are elevated into position, one by one, by the oil circuit breaker elevator and are then bolted together. The new arrangement is but two-thirds as wide as the original arrangement. Twenty-five bays of this later design are now being built for the Powerton Power Station of the Super Power Company of Illinois located near Peoria, Illinois and it will be used on future extensions at State Line Station.

The main objects of the metal clad design were to provide a structure that would

1. Insure maximum safety to the operating and maintenance personnel.

2. Provide a thoroughly reliable switching equipment by reducing to a minimum the chance of a phase-to-phase short circuit, and

3. Reduce costs (a) by eliminating the switch house building; (b) by providing a switching arrangement that would lead toward standardization and would be susceptible of mass production as a complete factory-built unit. This will naturally tend to cut factory costs and to eliminate a great deal of field construction which is often done under adverse conditions.

It is felt that these objectives have been achieved.

In the development of this new type of bus and switching structure, advice was sought from and was freely given by many engineers and manufacturers,

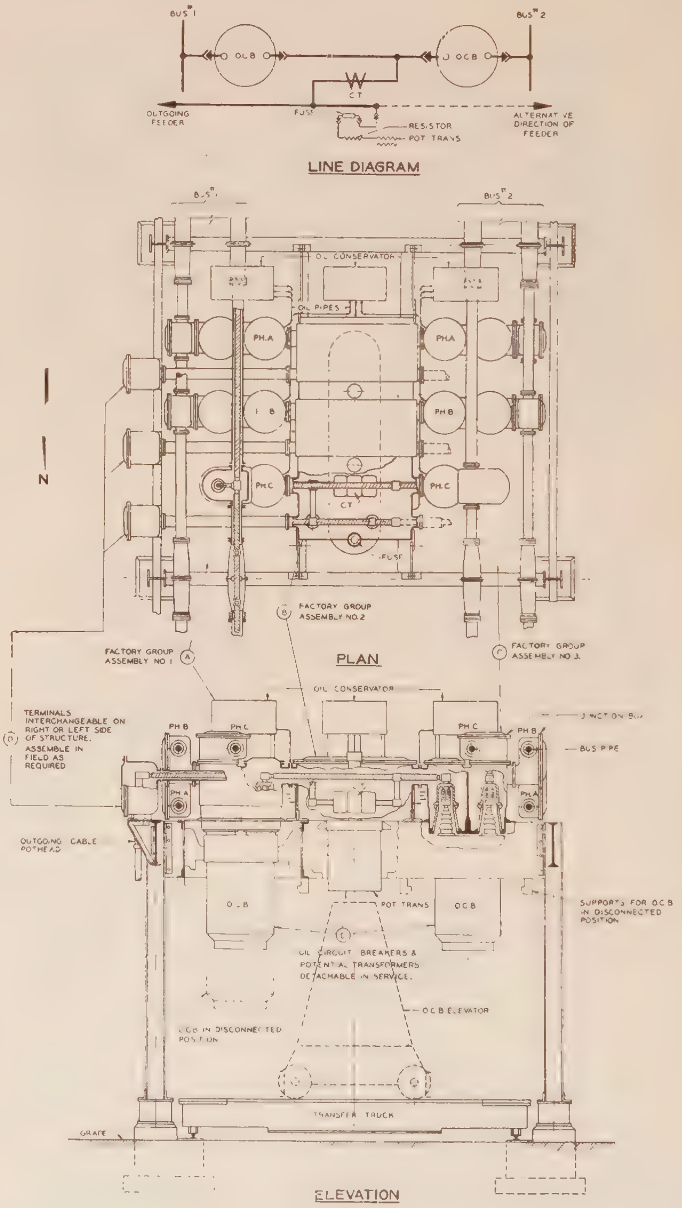

Fig. 8—Metal-Clad Switchgear Proposed for Unit No. 2—State Line Station

both in this country and abroad. Special acknowledgment is due the General Electric Company for the interest it has shown in this new design and for the careful attention it has given to the manufacture of the State Line equipment to insure the success of this new and somewhat radical departure from customary engineering practise.

Abridgment of

Induced Voltage of Electrical Machines

BY L. V. BEWLEY[1]

Associate, A. I. E. E.

Synopsis.—The object of this paper is to describe and discuss a general equation for the induced voltage of electrical machines having parallel coil sides, and which includes as special cases single- and polyphase-induction motors, synchronous generators, d-c. generators, synchronous converters, and static transformers. The application of the general equation to most of these cases is illustrated, and a number of interesting problems which may be solved by means of it pointed out. A characteristic of this equation is that no restrictions are placed on the velocity of the moving conductors, or on the rates of pulsation and rotation of the flux; but these may vary in any arbitrary manner which can be given a suitable analytic expression. The several methods for the reduction of harmonic voltages are classified and their limitations discussed in such a way as to leave in mind a vivid picture of the process. Tables and curves have been prepared for comparing the effects of the skew, pitch, distribution, and phase connection harmonic reduction factors. A new method for summing the finite series of the distribution summations is given in Appendix II of the complete paper.

* * * * *

Introduction

The purpose of this paper is to derive and discuss a general equation for the induced voltage of electrical machines having uniformly distributed parallel coil sides moving through a distribution of flux which can be represented by a Fourier series. The equation is general in that the circuit considered may have any number of phases connected in series in any arbitrary manner, and any particular phase may consist of any number of uniformly distributed, fractional-pitch, skewed coil sides moving at variable speed through a distribution of flux which may pulsate and rotate at different rates. As special cases, this equation includes the processes of induction found in the more familiar types of electric power apparatus, such as synchronous motors and generators, induction motors, d-c. motors and generators, synchronous converters, and static transformers.

Incidentally, a study of the general equation derived in this paper permits making a critical review and classification of the available means for suppressing harmonics in the induced voltage by special arrangements of the windings. These special arrangements give rise to certain functions known as *harmonic reduction factors* which enter the equation as ordinary coefficients. Corresponding to the particular arrangement of the winding to which they apply, they are called the *skew, pitch, belt-distribution, and phase-connection* harmonic reduction factors, respectively. These same factors have almost an exactly analogous effect in suppressing the harmonics of armature reaction, but their consideration in that respect is outside the scope of the present paper.

II. General Discussion

If it is possible to express the distribution of flux in an electrical machine having parallel coil sides by the Fourier series

$$B = \sum_{1}^{\infty} \beta_k \sin k \left(\frac{x}{\tau} \pi + \gamma_k \right) \qquad (1)$$

then the most general equation for the induced line voltage, regarding x_0, β_k, and γ_k as functions of time, is shown in Appendix 1 (of the complete paper) to be

$$E_{line} = -2L \frac{\tau}{\pi} \frac{n N'}{10^8} \sum_{1}^{\infty} C_{ck} C_{dk}' C_{pk} C_{sk} \left[\frac{1}{k} \frac{d\beta_k}{dt} \sin k \left(\frac{x_0 \pi}{\tau} + \gamma_k + \psi_k' + \psi_k \right) + \left(\frac{d\gamma_k}{dt} + \frac{\pi}{\tau} \frac{dx_0}{dt} \right) \beta_k \cos k \left(\frac{x_0 \pi}{\tau} + \gamma_k + \psi_k' + \psi_k \right) \right] \qquad (17)$$

where the C coefficients are the harmonic reduction factors depending on the arrangement of the windings, defined in Table I.

TABLE I

	Reduction factor	Seat of the reduction
Skew factor.....	$C_{sk} = \dfrac{\sin k\, \lambda/2}{k\, \lambda/2}$	In the coil side
Pitch factor.....	$C_{pk} = \sin \dfrac{k\, p\, \pi}{2}$	Between coil sides of the coil
Distribution factor of belt....	$C_{dk} = \dfrac{\sin k\, c\, \delta/2}{c\,.\, \sin k\, \delta/2}$	Between coils of the phase belt
Connection factor..........	$C_{ck} = \dfrac{\sqrt{(\Sigma \sin k\, \theta_r)^2 + (\Sigma \cos k\, \theta_r)^2}}{n}$	Between phases

If the n phases of the connection factor are uniformly displaced by the angle ζ then

$$C_{ck} = \frac{\sin k\, n\, \zeta/2}{n \sin k\, \zeta/2}$$

1. General Transformer Engg. Dept. General Electric Co., Pittsfield, Mass.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930. Complete copy upon request.

which is then in the same form as C_{dk}, and the same set of curves will serve for both. Moreover,

$$C_{dk} \cong \frac{\sin k\,\zeta\, c/2}{k\,\delta\, c/2} \text{ if } \zeta \to 0 \text{ and } C_{ck} = \frac{\sin k\, n\, \zeta/2}{k\, n\, \zeta/2} \text{ if } \zeta \to 0.$$

Thus, under these limiting conditions, the three reduction factors C_{sk}, C_{dk}, and C_{ck} have the same form.

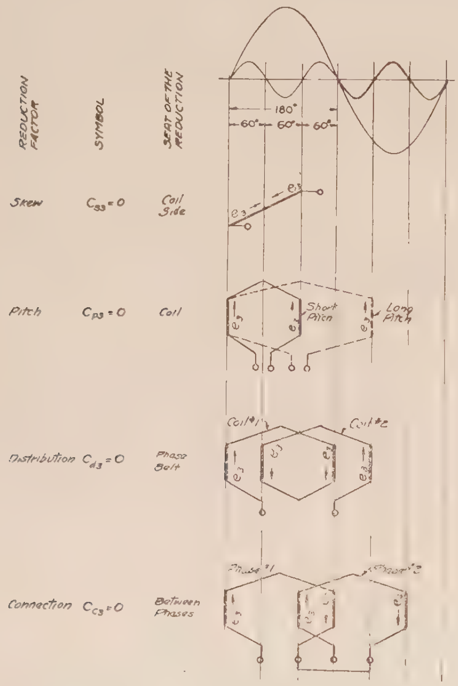

FIG. 1—SEAT OF HARMONIC REDUCTION

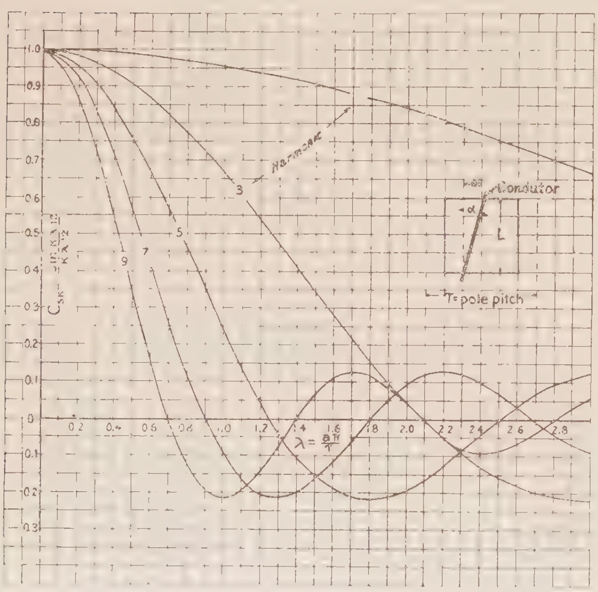

FIG. 2—THE SKEW COEFFICIENT

Associated with C_{dk} and C_{ck} are the distortion angles ψ_k' and ψ_k defined in Appendix I, and, in general, these cannot be made to disappear by a convenient choice of reference axes. In other words, a lack of symmetry and uniformity in the windings, or in the way that they are connected in series, will cause a distortion of the voltage wave by an angular shift in the relative positions of the harmonics, as well as by the reduction in amplitudes characteristic of symmetrical arrangements of the windings.

While these reducing factors have different names, they are, in fact, due to the same essential cause—the arrangement of the circuit so that the harmonic voltages produced in different parts are in partial or complete opposition and thus tend to cancel out over the complete circuit. Fig. 1 illustrates how this is accomplished in the case of a third harmonic.

If the conductor is skewed or spiralled, so that half of it is cutting through a positive loop and the other half through a negative loop of the harmonic of space distribution, then the voltages induced in the two halves of the conductor are always in direct opposition and therefore completely cancel within the conductor itself. The next simplest method of cancellation is to use a coil of fractional pitch so that both coil sides are

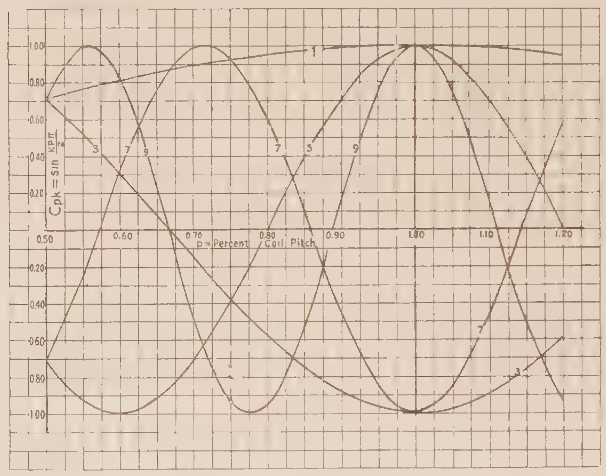

FIG. 3—THE PITCH COEFFICIENT

cutting through positive loops of flux, but the voltages generated thereby cancel in the coil. In this case, the coil may be either of short or long pitch. The distribution of the winding in more than one slot per phase gives rise to a reduction of the harmonic voltages between the coils which make up the phase group. Finally, it is possible to eliminate those harmonics which are multiples of the number of machine phases by connecting phases in series.

Representative curves of the skew, pitch, and distribution factors are shown in Figs. 2, 3, and 4, respectively, and the phase connection factor for a few simple cases is given in Table II. Only a number of harmonics sufficient to indicate the general nature of the functions has been plotted. It will be noticed that the maximum value which any of these coefficients may have is unity, or more appropriately, their value lies within the range $(-1 \leq C \leq +1)$, because they have not been defined as geometrical averages.

While β_k, γ_k, and x_0 in Equation (17) may be any arbitrary functions of time, yet the electromagnetic and

mechanical characteristics of electrical apparatus are such that for practical purposes, each of these items may be taken as composed of a series of terms of the type:

$$\beta_k = \beta_{0k} + \beta_{1k}\,\epsilon^{at} + \beta_{2k}\sin w\,t + \beta_{3k}\,\epsilon^{bt}\sin\omega\,t \qquad (22)$$

$$\frac{d\,\gamma_k}{d\,t} = v_{0k} + v_{1k}\,\epsilon^{a't} + v_{2k}\sin w'\,t + v_{3k}\,\epsilon^{b't}\sin\omega'\,t \qquad (23)$$

$$\frac{d\,x_0}{d\,t} = V_0 + V_1\,\epsilon^{a''t} + V_2\sin w''\,t + V_3\,\epsilon^{b''t}\sin\pi''\,t \qquad (24)$$

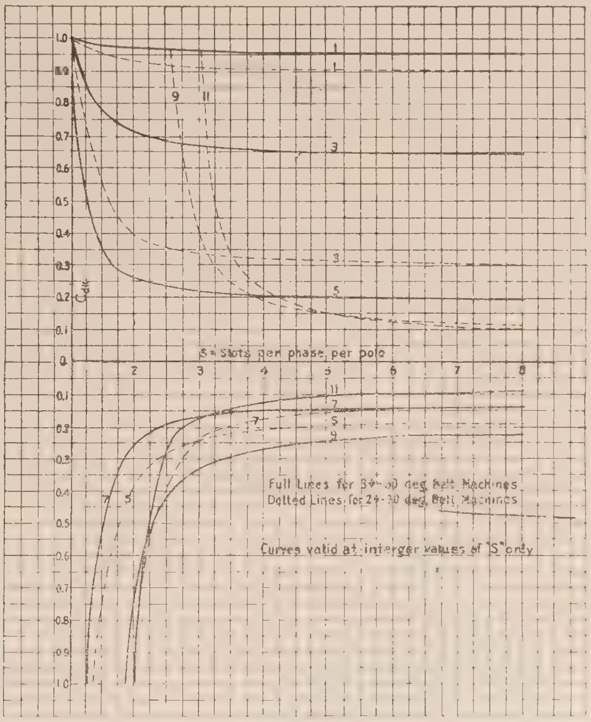

Fig. 4—The Distribution Coefficient

The direct substitution of (22), (23), and (24) in (17) yields a representative equation for the induced voltage in electrical machinery, but for the purpose of this discussion it is not necessary to carry out the actual substitution. It is sufficient to notice the following facts:

(a) When the flux distribution contains only rigid space harmonics, and when the coils are moving at a constant velocity; then only those time harmonics which are present in the space distribution of the flux, and which are not wiped out by the harmonic reduction factors can appear in the induced voltage. In this case, if any reduction factor for the kth harmonic be made equal to zero, then the kth harmonic will be canceled out of the induced voltage. But in general, if the slots are skewed or the coils made either short or long pitch, or if the total turns are distributed or phases are connected in series, every harmonic, including the fundamental, will suffer a reduction in magnitude. In brief, any departure whatsoever from a straight-sided full-pitch concentrated winding will cause a reduction of all harmonics. In particular, if the fundamental is canceled by any reduction factor, so will every harmonic be canceled.

(b) Depending upon the sign of the exponents, the presence of exponentials will cause either damped or cumulative oscillations to appear in the line voltage. The abrupt change of the excitation on a machine, either by rheostat adjustment or by an automatic voltage regulator, causes the flux to build up (or decay) exponentially. This change in β_k and its derivative is reflected in the equation for the induced voltage as exponential-trigonometric products; that is, as damped or cumulative oscillations. An exponential variation of β_k may be caused also by a symmetric short circuit

TABLE II

THE PHASE CONNECTION COEFFICIENT AND ANGLE

Connection	k =	1	3	5	7	9	11	13	15	17	19
3 φ Delta	C_{ck}	1	1	1	1	1	1	1	1	1	1
	ψ_k	0	0	0	0	0	0	0	0	0	0
3 φ Y	C_{ck}	$\frac{\sqrt{3}}{2}$	0	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{2}$	0	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{2}$	0	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{2}$
	ψ_k	+30°	0	+30°	−30°	0	+30°	−30°	0	+30°	−30°
2 φ	C_{ck}	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$
	ψ_k	+45°	−45°	+45°	−45°	+45°	−45°	+45°	−45°	+45°	−45°
6 φ Star	C_{ck}	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{2}$
	ψ_k	−60°	0	+60°	−60°	0	+60°	−60°	0	+60°	−60°
3 φ Zigzag	C_{ck}	$\frac{3}{4}$	0	$\frac{3}{4}$	$\frac{3}{4}$	0	$\frac{3}{4}$	$\frac{3}{4}$	0	$\frac{3}{4}$	$\frac{3}{4}$
	ψ_k	−60°	0	+60°	−60°	0	+60°	−60°	0	+60°	−60

or abrupt change of load occurring on a generator. If the torque of the prime mover driving a generator or the mechanical load on a motor changes, an adjustment in speed takes place. This speed transient will contain an exponential term due to the mechanical inertia of the rotating parts. In the case of power suddenly shut off from an open-circuited generator, the speed decrement is practically a pure exponential—but not rigorously so, because the friction is not constant throughout the speed range. These exponentials in speed cause the amplitudes of the harmonics in the induced voltage to change proportionally, and the wavelengths of these harmonics either contract or expand according to an exponential law.

(c) Perhaps the most important class of time variations in flux and speed are those of a purely oscillatory nature. Periodic fluctuations in flux are caused by sustained unbalanced short circuits and unbalanced loads on polyphase machines, the time harmonics of polyphase armature reaction variation in the air-gap reluctance due to the passage of teeth and slots, and the elliptical rotating fields of single-phase motors.

Any possible product of sine and cosine terms may be

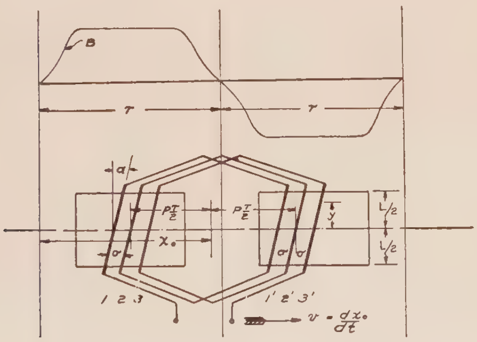

Fig. 5—General Arrangement

expressed as the sum or difference of sines or of cosines; for example

$$2 \sin w\, t \,.\, \sin k\, w_0\, t = \cos\,(k\, w_0 - w)\, t - \cos\,(k\, w_0 + w)\, t$$

It is of importance to observe from relationships of this type that it is quite possible to produce a harmonic of any order K (integer or fractional) in the induced voltage, even though the reduction factors have been adjusted for its complete cancellation. These possibilities are given by

$$w_0\, K = (k\, w_0 \pm w)$$

For instance, suppose that the reduction factors will wipe out the 5th time harmonic due to a 5th space harmonic of flux distribution. But as a possibility

$$5 = (k \pm w/w_0)$$

from which it is evident that the 5th time harmonic may nevertheless appear in the line voltage if the air-gap flux contains a space fundamental, $k = 1$, pulsating at w/w_0 = four times normal frequency, or a 3rd space harmonic pulsating at w/w_0 = twice normal frequency; or, in general, a kth harmonic pulsating at $w/w_0 = \mp (k - 5)$ times normal frequency. More generally, since the periodicity of the flux pulsation may be arbitrary, it is possible to produce frequencies in the induced voltage which are not multiples of each other.

The only common sinusoidal fluctuations in speed that occur in practise are those due to sustained hunting of synchronous machines, and prime movers or drives with cyclic torques (reciprocating engines, compressors, etc.).

From Equation (**17**) it is seen that such cyclic variations in speed affect both the amplitudes and wavelengths of the induced voltage.

(d) Finally, there is the class of time variations in flux and speed represented by damped (or cumulative) oscillations. Each of these appear in the voltage as a pair of damped (or cumulative) oscillations of different frequencies. They are caused by hunting, pulsating speed regulation by the governors of prime movers, and unsymmetrical short circuits of polyphase machines.

III. Applications

Under this section of the complete paper the application of Equation (**17**) to some of the more familiar types of electrical machines is illustrated.

List of Symbols

B = instantaneous flux density
L = effective length of stacking
n = number of phases in series between lines
N' = number of turns per phase
p = per cent pitch
x = coordinate of any point in the direction of motion
x_0 = coordinate of the midpoint of the first coil group
α = mechanical angle of skew
β_k = instantaneous amplitude of the kth harmonic of flux density
γ_k = instantaneous displacement angle of the kth harmonic of flux density
δ = electrical angle between coil sides
ζ = angle between adjacent phases
θ = displacement angle of a phase
λ = electrical angle of skew
τ = pole pitch distance
ψ_k = shift of the kth harmonic due to phases in series
ψ_k' = shift of the kth time harmonic due to dissimilar belts

FRENCH RAILROAD ELECTRIFICATION

Reports from France state that by 1932 about one-fifth of the railroads will be electrified. This movement which was interrupted by the war and by subsequent financial conditions is to be resumed actively in 1930 and 1931.

It is planned to electrify all of the French railroads eventually except those near the German frontier. There are now 1400 km. being equipped for electric operation, including 915 km. for the Midi, 250 km. for the Paris-Orleans and 100 km. for the Paris-Lyons railway. The balance is for the state-owned roads.

Abridgment of

Recent Developments in Toll Telephone Service

BY W. H. HARRISON[1]

Associate, A. I. E. E.

***Synopsis.**—This paper deals principally with the physical and technical phases of the development in recent years of "toll" telephone service in this country, with particular emphasis on the longer haul or "long distance" traffic. The very rapid growth in toll telephone business has required a rapid extension of toll plant, including outside plant, buildings, and switchboard and other equipment. The most striking developments in the outside plant are very great growth in toll cable networks and the rapid extension of the carrier telephone systems. The factors involved in the relative use of these various types of plant are discussed. An outline is given of the advance planning and study necessary to insure that these annual programs are properly engineered so that as closely as possible they will effectively anticipate future requirements and extensions in a most suitable and practicable manner. The more important limitations affecting the design of toll plant from the standpoints of the efficiency, quality, speed, and length of telephone transmission, and the specific treatments of each, are generally discussed in the paper. These include such matters as the use of loading coils, vacuum tube repeaters, equalizers for attenuation and phase distortion, and means for reducing the effects of echoes and time lag or delay in the circuits. Mention is also made of modifications of the open wire plant to effect material reductions in crosstalk, and to permit thereby a substantial increase in the use of carrier telephone facilities.*

The paper discusses the extension of toll service to include connection with the telephone networks in other countries, including Canada, Mexico, Europe, Cuba, and South America.

THE term "toll" is applied broadly to telephone service between different localities, as contrasted with "local" service which is, in general, within one municipality or center of population. From the early days of the telephone business the growth in toll service has always been rapid. This growth, however, has been particularly marked during the last few years. It is the purpose of this paper to outline briefly some of the plant design and other engineering problems associated with the present rapid growth of this service.

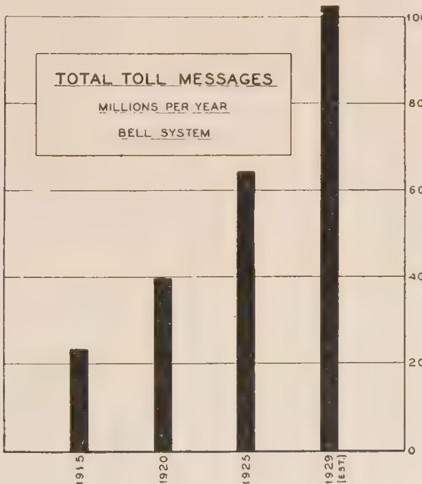

Fig. 1

Magnitude of Growth

The growth of toll telephone business is illustrated by Fig. 1, which shows the telephone toll messages per year in the Bell System for a number of years. This growth is perhaps more strikingly shown in Fig. 2, which gives in terms of cost the gross additions to toll plant per year for the last few years and the estimated expenditures for 1929.

A remarkable feature of the increase in the toll business is the fact that the largest increases are being felt in the very long distance business, particularly on the transcontinental routes and the routes between the largest cities in the various parts of the country. A typical example of this growth is illustrated on Fig. 5, which shows the growth in messages for the combined toll business over the transcontinental routes between Chicago and New York and Los Angeles and San Francisco over the same period. It will be noted that while the toll business in the system as a whole has increased 34 per cent over the last three years, the combined transcontinental business has increased 226 per cent. These increases in toll messages have required considerable enlargement of the size of the circuit groups between distant points and have contributed largely to the major construction problems in the design and layout of the plant.

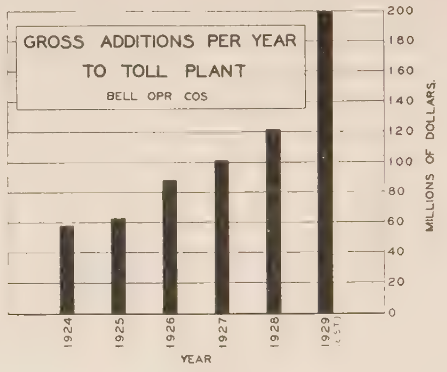

Fig. 2

The influence of the good level of general business in all parts of the country; the increasing public appreciation of the extent to which telephone toll service is of

1. Plant Engineer, American Telephone & Telegraph Company, New York, N. Y.

Presented at the Great Lakes District Meeting of the A. I. E. E., Chicago, Ill., Dec. 2-4, 1929. Complete copy upon request.

29-150

value in both business and social life; and the limitation of increases in telephone rates to a much lower percentage than the general level of prices have all been factors in the recent rapid toll growth.

Considerable added stimulation to the growth of the toll business has undoubtedly resulted through improvements in the quality of the service given. Possibly the most important improvement in this respect is the increase in the speed of the service; that is, the decrease in the time which elapses between the placing of a call and its completion. This is shown in Fig. 6. The improvement is greater for the long distance calls than for the toll service as a whole, the average speed for the toll board traffic being about 2½ min. in 1928 as compared with almost 7 min. in 1925.

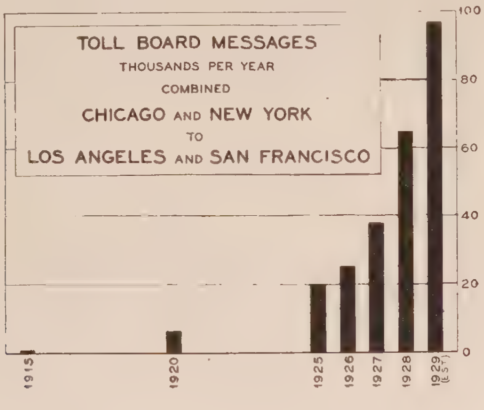

Fig. 5

The increase in the speed of handling toll service has been largely brought about by the introduction of improved operating practises and facilities which have permitted the use of simplified methods of operation similar to those employed for local business. The result of the materially faster service has been that over 95 per cent of the total toll messages are completed or reported upon while the subscriber remains at the telephone, without requiring him to hang up and be called again.

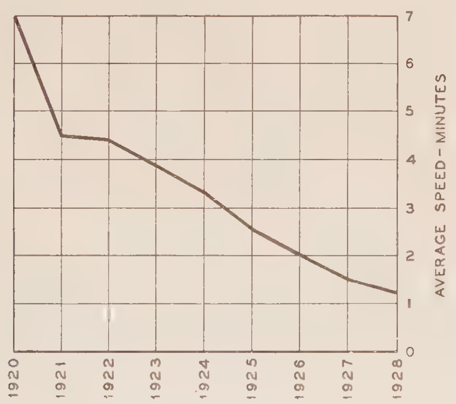

Fig. 6—Average Speed of Toll Service

Another important improvement in the quality of service has been brought about both through large increases in the volume of sound delivered at the end of the toll circuits and by improvements in the design of circuits, resulting in the greater distinctness and naturalness of the messages. This has included the use of methods providing for the efficient transmission of a much larger proportion of the component frequencies which make up speech. These improvements have largely reduced the percentage of messages in which the clearness of transmission is judged to be unsatisfactory, this being at the present time about 1 per cent for the total toll traffic.

Other improvements in service have led to greater freedom from the possibility of interruption of the service and to its improvement in other respects.

Additions to Plant

The rapid growth in the toll business has required a great expansion of the toll plant and has been accompanied by material changes in the character of the plant and in the nature of the engineering problems. This expansion has been particularly marked in the case of the toll cable plant, additions to which have been experienced in practically all parts of the country. An interesting illustration of this expansion is given in Fig. 7, which shows the relative proportions of the three important types of toll plant at the end of 1928 and the estimated trend for this year and the immediate years following.

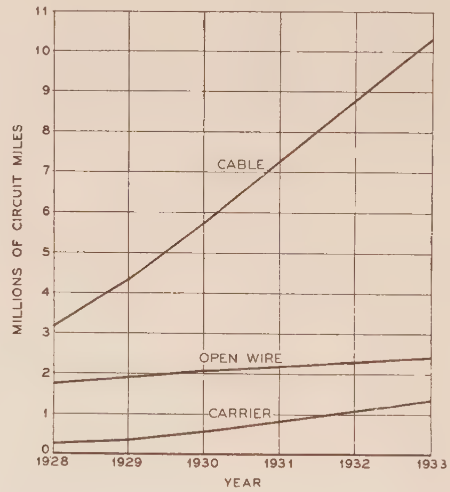

Fig. 7—Estimated Toll Circuit Miles in Plant Bell Operating Companies

Toll Cables

The extension of the toll cable program over the next five-year period contemplates cable on a large proportion of all of the major toll routes of the country. The magnitude of the proposed cable networks is shown in Fig. 8, which illustrates the main toll cable routes of the United States and Canada. It will be seen that in accordance with these proposed five-year plans, toll

cable will extend entirely across the continent and up and down the length of both the Atlantic and Pacific Coasts, as well as practically from Canada to Mexico in the central part of the country.

The toll cable which will be installed in the Bell System this year will amount to nearly 5000 mi. This amount will be increased to between 6000 and 7000 mi. for next year, and it is expected that the yearly additions will continue at that rate or even higher for the next few years thereafter.

Types of Cable Construction

Both aerial and underground methods of toll cable construction are widely used, the construction at the present time being about equally divided between these two general types. The greater part of the present longer haul toll cables are of the aerial type. In the aerial construction, the cable is suspended from a steel messenger strand supported on poles.

The underground type of construction up to the present has consisted for the most part of cable drawn into multiple duct, usually of vitrified tile, although in certain sections of the country some use has been made of creosoted wood duct. Naturally, the underground construction has been employed in cities and metropolitan areas and in heavy and rapidly growing cable routes where the provision of facilities for placing a number of cables within a reasonable period of time is important.

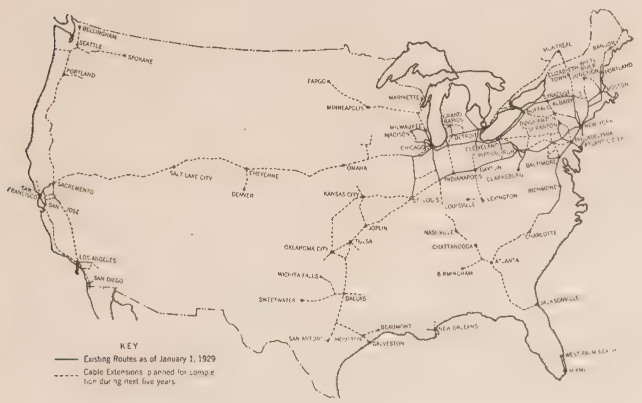

Fig. 8—Main Toll Cable Routes of the United States

During the past year trial installations have been made of two new types of underground construction designed to meet conditions where one or two cables will handle the requirements for a considerable number of years. One of these consists of a lead sheath cable pulled into a single fiber duct. In the other, a specially protected cable is buried directly in the ground without the use of ducts. The protection known as tape armor is applied over a lead covered cable of conventional design, the armoring consisting of coverings of impregnated paper, jute, and steel tapes which safeguards the lead sheath from soil corrosion and mechanical damage. This type of buried construction appears to have advantages for some conditions where the rate of growth is not rapid. One interesting characteristic is reduced susceptiveness to inductive influences due to the shielding effect of the armor.

The large annual additions to the toll cable plant necessitate the utmost care and precaution in planning and carrying out the construction and maintenance of this plant. The selection of the route for a toll cable is a matter of great importance, involving consideration not only of first cost and annual charges but freedom from inductive disturbances, permanency of routes, accessibility, and good coordination with existing telephone plant.

Aerial Wire and Carrier

In spite of the magnitude of the toll cable program, it is expected that in order to meet the demand for additional toll circuit facilities, it will be necessary this year to string about 180,000 conductor mi. of open-wire facilities and to install about 200,000 channel mi. of carrier telephone facilities. The majority of this wire stringing will take place of course on existing open-wire lines not closely paralleled by toll cables. The open-wire and carrier circuits now being designed are high grade facilities and their service characteristics and economies are such that a considerable portion of the open-wire and carrier facilities will be retained after they are paralleled by new toll cables.

Major problems presented by the open-wire and carrier construction have been those of crosstalk in the carrier circuits and noise in the very long voice-frequency circuits. It has been necessary therefore to give careful consideration to transposition methods and wire arrangements which would provide satisfactory crosstalk reductions and at the same time allow a maximum use of carrier facilities so that the large economies involved in superposing carrier telephone facilities on the open-wire plant may be obtained.

This has resulted in trying out in the plant an entirely new form of open-wire construction. The new method involves abandoning the phantoms on the open-wire pairs on which the carrier facilities are to be superposed, reducing the spacing between the wires of these pairs to 8 in. and widening the spacing between the wires of adjacent pairs to 16 in. The pairs to be used with carrier facilities are transposed in accordance with transposition systems which are especially designed to reduce adequately the coupling between the pairs at the higher carrier frequencies. The experience obtained to date with this type of open-wire construction, while not conclusive, has indicated very favorable cross-talk results. The reduction in the spacing of the open-wire pairs has also resulted in material improvements in the noise on the voice-frequency circuits. Under this arrangement, four three-channel carrier telephone systems can be employed per crossarm. The pole pair groups are not normally used for carrier telephone purposes and may therefore remain on a phantomed basis.

Other considerations in the use of long haul carrier telephone systems have been those which have led to the development of improved glass insulators which materially reduce the attenuation at carrier frequencies and substantially limit the variations in attenuation between wet and dry weather conditions; and pilot channels by which the levels at all points in the carrier systems are maintained within established limits. As changes in line equivalents affect both the pilot frequencies and the speech channels in a related manner and are indicated on calibrated meters, compensating gain adjustments may be made.

Electrical Design Features

The development of very long toll telephone circuits has involved working out a succession of very interesting design features in order to obtain suitable electrical characteristics for the clear transmission of speech over these long circuits. These problems, in general, have been particularly great for very long toll cable circuits. A brief review of the general nature of some of these problems and the method of solution adopted for toll cable circuits will be sufficient here.

In the early extensions of toll cables, the use of "loading," by means of which the attenuation was made much more nearly constant over the band of frequencies most important for the transmission of speech enabled satisfactory transmission over relatively short circuit lengths. Subsequently, the range of cable transmission has been increased to practically an unlimited extent by the perfection of telephone repeaters employing vacuum tubes.

Another important problem in the longer circuits has been the prevention of changes in efficiency with variations in the temperature of the circuit. The importance of this is illustrated by the fact that the energy loss in a Chicago-New York toll cable circuit may be as much as 10^9 times as great when the circuit is hot as when it is cold. The daily, and even the hourly, variations are sufficient to cause large variations in efficiency if not compensated. This compensation is done by the automatic change in the gain of amplifiers which is controlled by the resistance of pilot wires running through the cables and subjected to the same variations in temperature as the circuits used for message purposes.

Another phenomenon which becomes of importance with increased length of circuit is the variation in the velocity of propagation over the circuit of different components of speech. The components of moderate frequency (about 1000 cycles) tend to arrive at the distant end first, those of higher and lower frequencies trailing in later. This produces an additional type of distortion. Some of this distortion can be minimized by improvements in the design of the apparatus. The use of corrective networks which insert in the circuit a distortion in velocity of transmission compensating that caused by the cable circuit characteristics is also being studied to take care of this situation.

Looking to the future, it appears that the limit of transmission over telephone cable circuits may be influenced by the operation of another and still more fundamental factor; namely, the time required for the transmission of electric currents over these very long circuits. With the development of toll cable networks covering this country and Europe, and with the completion of telephone cables across the Atlantic, total distances of transmission over toll cable circuits as great as 10,000 mi. will probably be involved in the future. The types of cable circuit now used for very long distances have a velocity of propagation of about 20,000 mi. a sec. The time lag in a 10,000-mi. cable circuit would be about half a second for transmission in each direction. A delay of this magnitude would interfere with the ordinary methods of conversation involving frequent acknowledgment, interruption and interchange of question and answer. Looking forward to improving such conditions, research work is now under way to determine the best means of providing cable circuits of still higher velocities.

International Connections

The toll system of the United States now has connection with telephones in 21 other countries. By this means the users of this service are offered connection with 65 per cent of all of the telephones in other countries of the world or 85 per cent of all the telephones in the world including those in this country.

Perhaps the most interesting of all the individual connections which include circuits to Canada, Mexico, Cuba, and Europe, is that between New York and London. In 1927 the first commercial service was opened between the United States and Europe by a circuit from New York to London. This has since been supplemented by three additional circuits and other additional circuits now planned will raise this group to six by the end of 1932. The first circuit includes for the transatlantic link a long wave radio system transmitting from points near New York and London to receiving stations in the eastern central part of Scotland and northern part of Maine, respectively. The other three circuits are short wave radio circuits, both transmitting and receiving stations being near the New York and London terminals.

These circuits, both the long wave and short wave, are of pioneer character. The effort has been to obtain as good a degree of continuity of service as transmission conditions will permit and consistent with requirements for satisfactory commercial services. In working to secure this result one is, of course, faced with the very large variations in efficiency of transmission under various conditions and also in the magnitude of the interfering atmospherics which tend to interfere with good reception.

The short wave channels are, in general, less affected than the long wave by high atmospheric disturbances, but are much more affected at times of magnetic storms when large variations in the field strength of the signal

at the receiving antenna often occur. Fortunately these two types of disturbances seldom appear at the same time and the two types of radio channel admirably supplement each other in the maintenance of uninterrupted service.

Work is now proceeding in the design of a transatlantic telephone cable which will provide a third type of circuit between New York and London. For this cable, transmission will probably be overland from New York to Nova Scotia; thence by submarine cable to Newfoundland; by a second cable 1800 mi. in length from Newfoundland to the Irish coast, and from there to London. This cable presents so great a departure from previous telephone circuits that extensive research and development are necessary to determine the most favorable methods of construction.

An additional international connection which is now being constructed is of interest: namely, a short wave radio telephone channel between New York and Buenos Aires, connecting with Montevideo.

Planning for the Future

From the general engineering standpoint, the plans for the continued expenditure over a period of years of large amounts for permanent extension of toll plant, call for very careful attention to the fundamental planning and layout of that plant. This is particularly true in view of the large extension of toll cables and of underground toll cable conduit routes in which best engineering requires that initial construction be designed with a view to the future increase in circuit requirements for a relatively large number of years. This, then, is one of the important features of the engineering work of the Bell operating companies at the present time.

While fundamental plans for future development of toll plant must adequately provide for the plant extension in a given area, they must be closely coordinated with each other and with the plans for the country as a whole, particularly because of the importance of the large groups of long through toll circuits.

Conclusion

In conclusion, I might add that those of us who are closely interested in the advancement and improvement of the toll phase of the telephone business look forward to a continued rapid development of that part of the communication art with an increasingly complex and varied engineering technique.

Economics of Production[1]

BY DEXTER S. KIMBALL[2]
Non-Member

I ESTEEM it no small honor to be invited to give this memorial lecture; and it is a great personal pleasure for me to do what little I can to keep green the memory of the great scientist, humanist, and engineer in whose honor these lectures have been founded. It was my great privilege to be quite well acquainted with Doctor Steinmetz and, as you know, to be acquainted with him at all was to admire him unreservedly.

It is quite remarkable how this little, frail, and misshapen man impressed his genius upon the field of science during his life time, and has made all men who shall work in the field of electrical engineering for all time his debtor. It is even more remarkable how he drew to himself a host of friends from all walks of life. When Steinmetz spoke, the whole world listened. He was indeed a man of genius whose like will not be seen again in many years, and you, here where he labored so long and was so much beloved, indeed do well to honor his memory.

I am in no sense a scientist such as he, and I cannot make any such contributions to the field in which he was so well known as those who have preceded me have done. Fortunately, however, Doctor Steinmetz did much in the field of thought in which I am most interested. Not only was he interested in the design and production of industrial machinery but he recognized as few men do that such machinery is of importance only as it affects humanity; and he was constantly speculating as to the ultimate result of our machine civilization. You will all remember his prophecy that eventually the world's work would be performed in four hours daily,—a prophecy that is in a fair way of being realized. In honoring his memory, therefore, I cannot do better than to call your attention to some of the newer developments in the application of the laws of economics to industrial production.

The last half of the 19th century witnessed a most remarkable development in the tools of production. The last quarter of a century has been marked by the creation of vast industrial enterprises employing thousands of men and impressive machine equipment, and presenting three new industrial problems; namely, mass production, mass financing, and mass management. It is of certain phases of this latter field that I shall speak.

During this last quarter century, a voluminous literature has appeared presenting many theories of management and administration, and many of these new

1. Fifth Steinmetz Lecture, delivered before the Schenectady Section of the A. I. E. E., March 8, 1929.

2. Dean, College of Engineering, Cornell University, Ithaca, N. Y.

ideas have found a permanent place in our industrial economy. Without doubt we are much better informed concerning many phases of industrial organization than we were a few years ago and there is some ground for the assertion that there is a science of management and that we are making some progress toward an understanding of its basic laws. On the other hand, there is no doubt but that many of these new experiments are empirical, and less doubt that the true economic basis of many of the mechanisms of management, concerning which so much has been written, are but dimly understood. As tangible proof of this statement, one has only to consider the large number of industrial concerns that pay no dividends. More significant still, Bradstreet reports that of the 20,267 failures in the United States last year, over four-fifths of such failures were due to incompetence of some form upon the part of those failing. There is great need therefore for a better understanding of the economic basis of industry, and a strong movement in that direction is now under way. The next decade will no doubt see the development of the economics of industry as against the mechanisms of production. Consider the following economic principles that are well established though not always well understood:

1. The unit cost can in general be decreased as the quantity to be produced increases.
2. Production in general depends upon more than one factor and usually it is possible to utilize the full capacity of any one factor only be permitting other factors to operate at lower capacity or efficiency.
3. Every economic gain is apparently accompanied by a corresponding loss which tends constantly to neutralize the effect of the economic gain; hence it becomes increasingly difficult and costly to utilize the full capacity of any productive factor.

The first of these statements is the basis of quantity or mass production and needs little explanation except to point out that it has limitations, these limitations appearing usually as the result of the third principle or law of diminishing returns, as it is usually called.

The second principle is not so well known or appreciated. It can be visualized best by actual examples. Thus, a large boring mill considered as a major productive factor must be served by a number of minor factors, such as light, heat, power, crane service, etc., none of which, in general, operate at high efficiency even when the mill may be operating at capacity. Or again, if a large number of machines is to be kept in perfect repair, the repair gang must be so large as to work inefficiently at times. Or, conversely, if the repair gang is so small as to work at high efficiency, there is a likelihood that some of the machines will at times be idle.

The third principle is so well established as to need no discussion, but a simple example may make it clearer. Consider, for instance, an office building with elevator service. For a given number of floors and a given quality of service, a certain proportion of the floor space must be given up to the elevator shaft. If additional floors are added, the amount of space allotted to the shaft must be enlarged for the given service and the space available for rental proportionately decreased. Obviously, if the building could be made high enough, the entire floor space, if the service is maintained, would have to be devoted to shafts. As more floors are added, the elevators could of course be speeded up, and the amount of shaft space could thus be somewhat reduced. But here again there are limitations to the speed at which elevators may be operated, and eventually the law of diminishing productivity asserts itself, and as successive floors are added, reduces the income per square foot of floor space.

The first principle is usually known as the law of increasing productivity, while the last is usually referred to as the law of diminishing productivity, or the law of diminishing returns. This is a somewhat unfortunate nomenclature as it gives the impression that these laws are opposing influences whereas such is not the case.

Diminishing returns refer to the relations between the productive factors, as bushels per laborer or pounds of fertilizer; or to rental per square foot or floor area. Increasing returns or increasing productivity refer to the reduction of cost due to the influence of all factors concerned, and in the case where several factors are in effect, the law of diminishing returns may be operative, while at the same time the unit cost may be decreasing. As Professor J. M. Clark truly states, "Decreasing yield per acre does not condemn intensive farming if it brings increased yield per acre, for, where land is expensive, the net result may be an economy. In quite the same way, overtime work in a factory may bring decreased yield per hour of direct labor or per dollar spent on direct labor but the total cost per unit may be reduced."

An actual example may make these relations clearer: Assume that a certain factory is equipped with 50 machines, each operated by a skilled worker who receives \$5 a day, and that under ordinary normal conditions each man is producing one unit of product daily. Assume that the fixed overhead or burden is \$150 daily and that the variable overhead is equal to one dollar per day per man employed. Assume further that the material cost per unit is \$3 and that the sales price is \$12 per unit. Then if all expenses are charged into the costs, the cost of the daily output will be made up of the sum of the fixed and variable daily expense, the daily wages and the cost of the material going into the daily output. For 50 operators and an output of 50 units, the daily cost of production will be

$$(\$150 + \$50) + (50 \times \$5) + (50 \times \$3) = \$600$$

Since the sales price is \$12 per unit and the output is 50 units, the daily income is $50 \times \$12 = \$600$, and the factory under these circumstances would be making no money.

Suppose, now, that the management decides to install a planning and transportation department, thus relieving the operators of certain auxiliary duties and leaving them free to drive the machines to a higher capacity; that is, the labor factor is to be increased and a greater division of labor introduced in order to force the major factors,—namely, the machines,—to higher production. Then the increase in production will follow a curve somewhat like A in Fig. 1, rising slowly as the first few men are added; then somewhat more rapidly, and then at a decreasing rate as more men are added. Suppose finally that when the tenth additional man is added, the maximum capacity attainable is reached and no number of additional men can force an additional unit from the plant during the working day.

The gain in the number of units produced as each man is added is measured by the vertical increments, such as m in Fig. 1, and these are plotted at the bottom of the figure, thus forming curve B. If the ordinates of

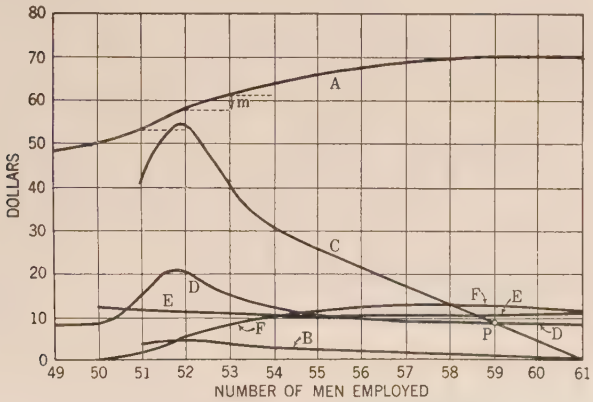

Fig. 1

curve B are multiplied by \$12, the sales price, curve C is obtained, showing the increase in income for each additional man above 50. The cost incurred in adding an additional man is found by subtracting the total cost for any given number employed from the cost of operating with one more. Thus in the foregoing it has been shown that the cost of operating with 50 men is \$600; the output with 51 men as shown by curve A is 53 units; hence, the cost of operating with 51 men is

$$(\$150 + \$51) + (51 \times \$5) + (53 \times \$3) = \$615$$

That is, the cost of adding the fifty-first man, or the *differential cost* as it is usually called, is \$15. Curve D is the curve of differential costs. It intersects the curve C in the point P. At this point, the cost of adding a man just equals the gain in income due to that addition, and beyond that point, the gain is less than the cost necessary to secure it. Curve E shows the unit costs for successive numbers of men employed. Its ordinates are found by dividing the cost of operation by the number of units produced; thus, when 51 men are employed, the total cost is \$615 and the output is 53 units. Hence the unit cost is $\frac{615}{53} = \$11.6$. The lowest unit cost occurs when 57 men are employed, and, naturally, its values rise after the point P is passed. It should be noted that this curve rises rapidly as the number of men is decreased below 50. Finally, curve F shows the net income or difference between the cost of production for any given number of men and the corresponding income from sales. The ordinates of the curve represent ten times the value of the scale shown. As might be expected, this curve reaches its maximum at or near the point where 57 men are employed.

It should be noted that the increase in production due to adding the fifty-second man is greater than that due to adding the fifty-first; that is, the factory is operating under *increasing returns.* But from that point on, the increase in output is progressively less as each man is added; or the factory is operating under *decreasing* or *diminishing returns.* Nevertheless, the total output is rising, the unit cost is falling, and the net income is increasing up to the fifty-seventh man; and up to full capacity of 70 units per day, if for reasons of policy that should be desirable, there is no great loss in income in operating. But the maximum income is obtained before the point P is reached. It is obvious that these relations are highly important. There is no doubt but that the most advantageous point of production is often exceeded, and many so-called "efficiency systems" have failed dismally for lack of a clear understanding of the interrelation of these basic principles.

If curve A of Fig. 1 could be expressed in mathematical form, the curves B and C could be deduced mathematically; and since the curve E can usually be expressed in mathematical form, the point P can be determined mathematically. Space does not permit of farther discussion of this procedure and at the present time it is of little importance as our knowledge of the general character of curve A is very incomplete.

This discussion is presented not so much for its practical application as to point out the trend of thought in manufacturing. There can be little doubt but that these methods will be of increasing importance as industry becomes more scientific in its background; and it is moving rapidly in that direction.

Furthermore, it accents the growing realization that the old empirical methods are passing away; and with them must necessarily pass the old empirical foreman and superintendent, wherever these advanced methods are applicable. Industrial management of the future must be more than *intelligent.* It must be *educated*; and all progressive enterprises not only realize this, but are making an effort, through foreman training courses or similar educational devices, to raise the educational level of their supervising staffs. They that do so will find the cost of such efforts money well expended, not only because of better control of production, but also because enlightened management makes for better and happier conditions in industry.

Abridgment of

Electrically Welded Structures Under Dynamic Stress

BY MORRIS STONE* and J. G. RITTER†

Non-member Non-member

THE general application of arc welding to all types of construction has extended rapidly during the past few years, but not in the field where dynamic stresses were imposed because of the lack of information on the fatigue resistance characteristics of such welded structures. Even as far back as 1911, Stanton[1] and Abell[2] after making a series of Wohler tests of welded material, advised against welds for variable stress applications. However, recent investigations such as those described in this paper, justify a more general increase in the use of welding under these conditions.

An active comparison of endurance limits as determined for varying sizes of welds is the object of a present research, and we need not be surprised to find the larger size welds showing lower endurance limits. Such an effect can be explained by the injurious influence of residual stresses in the larger welds, which do not occur in the smaller welds, where they can be relieved by the heat of subsequent welding. Such results would indicate opposite tendencies to those published for tensile strengths, yield points, etc.

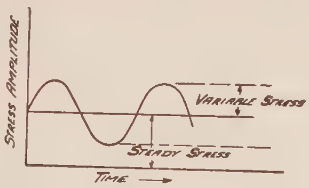

FIG. 1—DIAGRAM ILLUSTRATING COMBINED STEADY AND VARIABLE STRESS

From the widely differing values of endurance limit, it is entirely feasible to count on the value of $\pm$ 15,000 lb/in.^{2} This, it will be realized, must be compared with endurance limits of $\pm$ 25,000 lb. per sq. in. for mild carbon steel to as high as $\pm$ 60,000 lb. per sq. in. for some alloy steels.

Most structures are rarely subjected to purely variable stress—alternating between equal values of tension and compression—but rather combinations of steady and variable components as illustrated in Fig. 1. The failure of metals under such conditions is still a matter of investigation, and is only now becoming clarified from the point of view of design utility.

One of the most common stress conditions, and probably the most elementary for a material study, is that of simple tension or compression superimposed by a variable stress of smaller magnitude. Experiments, investigating failure under various ratios of steady to variable stress, have been carried out for many years, with certain characteristic relationships becoming evident. If we plot steady stress as abscissas versus variable stress as ordinates, the experimental curve of failure follows somewhat that shown by the dotted line in Fig. 2. This has been approximated to by Gerber as a parabola, and by Goodman as a straight line connecting endurance limit and ultimate stress, but it is more conservative and easier of application to use the straight line approximation shown connecting endurance limit and yield point.

The relation between allowable variable stress, S_v, and corresponding steady stress, S_s, as defined by the straight line is, where

S_e = Endurance limit

S_y = Yield point

$$\frac{S_v}{S_e} + \frac{S_s}{S_y} = 1$$

Now in the actual applications of arc welded structures, we do not permit ourselves to operate close to failure stresses; therefore the idea of factor of safety must be introduced.

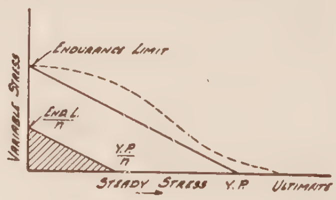

FIG. 2—CURVES SHOWING RELATION BETWEEN VARIABLE AND STEADY STRESSES

Due to the very many exigencies that may occur in welding, such as poor fusion, impurities, porosity, etc., we, in our design practise, have set a factor of safety of 3 to be used both on the yield point in steady stress applications and on the endurance limit for fatigue. This confines our stresses to the shaded area shown in Fig. 2 and our stress relation now is expressed by

$$\frac{S_v}{S_e} + \frac{S_s}{S_y} = \frac{1}{n} \quad (n = \text{factor of safety})$$

*Mechanical Engineer, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

†Welding Engineer, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

1. T. E. Stanton and J. R. Pannell, I. C. E., Dec. 1911.
2. W. S. Abell, I. C. E., March 1919, in an investigation for Lloyd's.

Presented at the Winter Convention of the A. I. E. E. New York, N. Y., Jan. 27-31, 1930. Complete copy upon request.

For welds, this relation takes on the quantitative aspect of

$$\frac{S_v}{15{,}000} + \frac{S_s}{30{,}000} = \frac{1}{3}$$

The endurance limit and yield point values being taken here are average figures.

To illustrate its use: Suppose we have a pure variable stress, then $S_s = o$, and the allowable S_v is given by

$$S_v = \frac{15{,}000}{3} = 5000 \text{ lb. per sq. in.}$$

On the other hand, suppose we consider a static application, where $S_v = o$, then the allowable stress, S_s is

$$S_s = \frac{30{,}000}{3} = 10{,}000 \text{ lb. per sq. in.}$$

These are the values adhered to in all designs where welds have to withstand live stress. An intermediate case may be: If $S_s = 5000$ lb. per sq. in., what is the allowable variable stress that may be superimposed? Thus

Allowable $S_v = \left(\frac{1}{3} - \frac{5000}{30{,}000}\right) 15{,}000 = 2500$ lb. per sq. in.

At this point, we must inject an idea extraneous to fatigue considerations for pure metals, but one which occurs when heat treated alloy steels are welded together or to ordinary steels. Tests that have recently

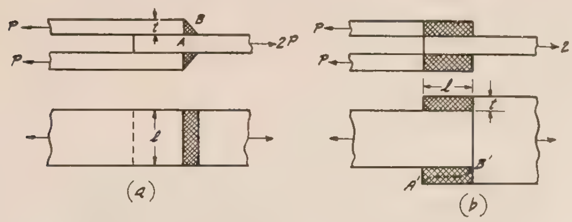

Fig. 3—Two Types of Welded Joints

been made consisted of welding a ring of metal around a heat treated ni-chrome steel (0.56 per cent Cr, 1.17 per cent Ni.) test bar, and then after machining off the bead, subjecting the bar to an alternating stress. The endurance limit dropped from 66,000 lb./in.^{2} (for the alloy steel) to 16,200 lb./in.^{2} Like reductions were noted in ductility and impact resistance. This important result emphasizes the point that the fatigue strength of welded joints cannot be increased by using high grade parent metal—the effect of welding is to reduce the endurance limit to only average values for mild carbon steel. This fact is important, particularly, where joints are designed to fail in the parent metal and not in the weld. This result, however, is not to be interpreted to apply in the case of static stress, where tensile properties do not appreciably change.

As soon as we begin to extend our ideas to welded joints, much of our knowledge becomes inapplicable. To interpret our information on weld and parent metal for use in welded joints is to assume that the stress distribution is known. This unfortunately is the stumbling block in most cases.

To examine the simplest of joints, let us compare the two types of joints shown in Fig. 3, the first, a joint of front welds and the second, a joint of longitudinal or side welds, as to their suitability to withstand dynamic stress.

From tests that have been made in the past, notably by Dustin, the strength of joint (*a*) is best predicted

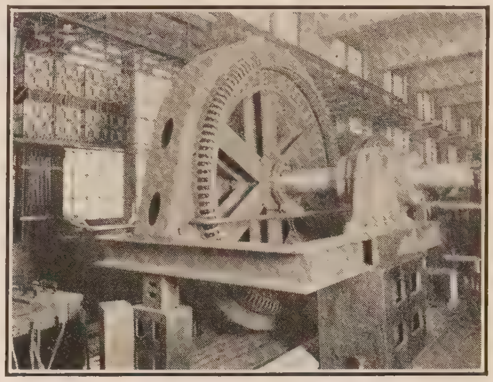

Fig. 4—Arc Welded A-c. Generator

by considering the section $A\ B$ to be subjected to pure tension and we must associate the stress given by

$$f = \frac{\sqrt{2}\,P}{t\,l} \text{ with failure.}$$

Failure usually takes place at this critical section. For type (*b*) welds, the breaking stress can be written as $f = (\alpha \sqrt{2}\,P)/(t\,l)$ where α has the value of approximately 2/3. This factor has this low value due to the stress concentration at the ends of the weld, causing the break to progress from A^1 and B^1 inward. Despite the lower allowable stress for joint (*b*) (where stress must always be compared with shear stress failure, while in (*a*) the much higher value of tension failure can be approached), it must be noted that the energy of rupture of joint (*b*), is much larger than that for (*a*), and Dustin even goes so far as to favor (*b*) over (*a*) for dynamic loading. A conclusion like this, however, is clearly a case of balance of ductility of break against allowable stress.

The design of machines to be constructed of structural shapes welded together involves a great many factors in addition to the direct stresses in the welds. Fig. 4 shows the type of construction widely used for a-c. generators and motors, the rotors of which are direct connected to geared machines or combustion engines. These machines are subjected to large torque variations of both high and low frequencies and a considerable amount of experimenting has been carried

out to determine the best arrangement of the structural members and welded connections.

It was quite easy to make the welds themselves efficient in these structures, but the stress concentration in the structual members was a serious problem. It will be noted that the H-beams of the rotor are placed so that the smallest moment of inertia is utilized for torque loads. This arrangement calls for larger beams but gives the most economical design to keep stress concentration at a minimum.

Fig. 5 shows several methods of fixing the H-beams into the hub of the rotor which were tested in a vibrating machine. This machine subjected the specimens to a very violent oscillating vertical motion corresponding to torque oscillations in the actual rotor. Specimen (*c*) proved to be the best, but specimen (*b*)

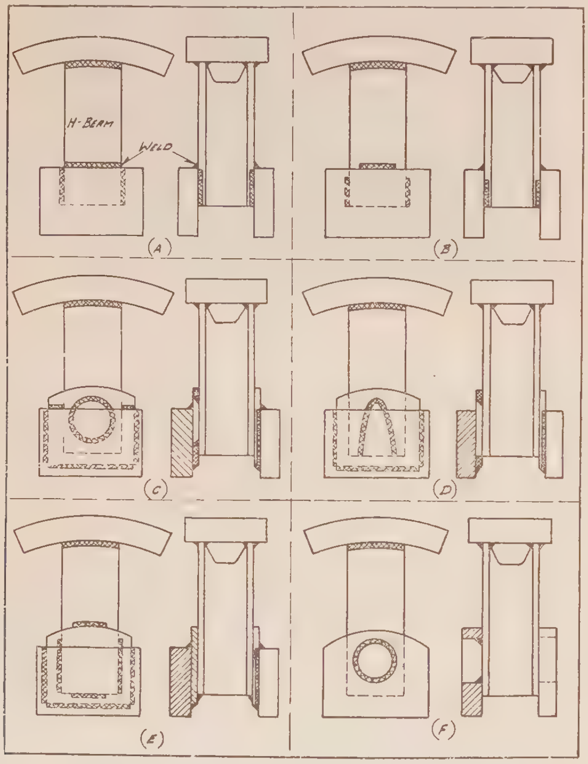

FIG. 5—SPECIMENS TESTED ON VIBRATION MACHINE

has proved satisfactory for normal applications. Further tests are being conducted on a machine which will give actual as well as relative values of the stresses encountered and will also permit the superimposing of initial stresses in the structure which are independent of the varying stresses.

The initial stresses which are encountered in welded structures proved to be very harmful when the structure is subjected to varying stresses as discussed earlier in the paper. These initial strains are caused by the actual shrinkage of the weld metal itself and by the unequal heating of the various parts of the structure while being welded. Bending and twisting strains are set up while cooling to room temperature. Many complete rotors were built to determine if it was possible to obtain a structure free from initial strains. The method used in determining the residual strains was to drill small gage holes in the pieces before being assembled and recording the variations in the distances between them after being welded. After the rotor was

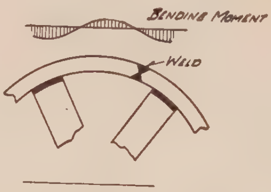

FIG. 7—WELD IN ROTOR RIM LOCATED AT POINT WHERE BENDING IS ABSENT

completed, additional strain gages were clamped to the structure at various places and the individual members cut loose from the structure by hack saws. Various

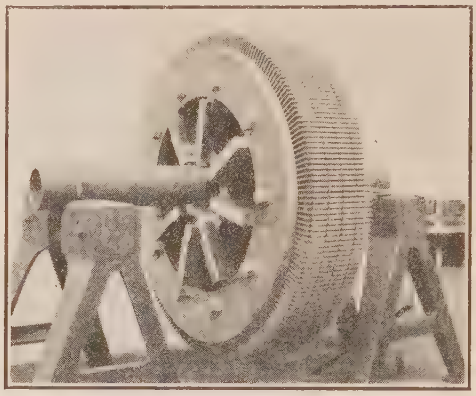

FIG. 8—1000-KW. ARC WELDED D-C. ROTOR

welding sequences, peening of welds, artificial cooling of members, and jigs were used, but it was found to be commercially impracticable to obtain a complete rotor free from high residual strains.

Annealing was then adopted in order to remove the

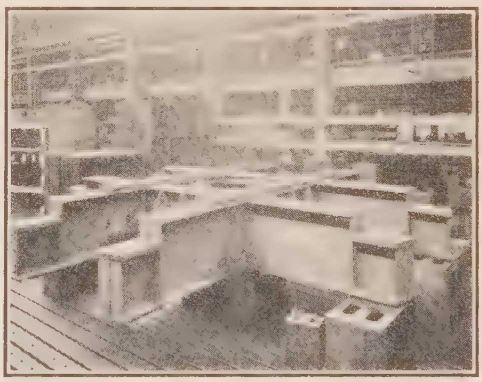

FIG. 10—25000-KV-A. LOWER WATERWHEEL BRACKET

strains and tests were made at various temperatures by our Research Dept. It was found that practically all residual strain was removed at 1000 deg. fahr. and this temperature was adopted for all welded apparatus where a strain free condition is necessary. Several complete rotors were annealed at 1000 deg. fahr. and the residual stresses found to be under 1500 lb. per sq. in.

Annealing at higher temperatures was found to be undesirable because of the greater liability of warping and cracking the welds. All of the physical properties of the weld itself are decreased by high temperatures and because of this it is not considered practicable to obtain refinement of the grain structure of the parent metal adjacent to the weld at the expense of the weld itself. These results concur with previous conclusions of other investigators.

It is of interest to note the design consideration necessary in the use of butt welds for the rims of the above mentioned rotors. These rims are made of bar stock rolled up and butt welded. It was at first thought desirable to locate the welds of one of the rotor arms across the butt weld in order to re-inforce it but the bending and tension stresses were above our allowable limit. The location of the weld as shown in Fig. 7 at a point where the bending in the rim is zero and only the centrifugal tension exists, made it possible to use a welded construction.

In Fig. 8 we have a typical arc welded d-c. rotor, 1000-kw., 300-rev. per min. for steel mill application. The construction here is characteristically different from the a-c. rotors in that there is no welded connection between the spokes and rim, thus eliminating the condition where locked up stresses are serious. This permits the use of welding without strain annealing and has been applied with complete success to Diesel driven generators, steel mill drives, ship drives, etc., all of a dynamic stress type. All machines of this type have been tested at repeated short circuit and maximum overspeed, and are designed to withstand a torque load of ten times normal.

Fig. 10 shows an arc welded bracket for supporting the rotor of a 25,000-kv-a. waterwheel generator. This type of bracket must be designed to permit a very small deflection and must withstand varying and shock loads. The waterwheel sets up considerable vertical vibrations and under certain operating conditions water surge impacts can be so severe that the rotor is actually lifted from its thrust bearing.

The unabridged paper contains several additional examples of dynamically stressed welded structures.

We have emphasized, in this paper, the degree to which electric welding may be relied upon in applications where the structure is subjected to dynamic stress. Such applications can be successfully made by giving due consideration to the factors of maximum working stress, residual welding stresses, and stress concentration. The pessimism of the past few years regarding dynamic applications is slowly disappearing and it is only by the careful consideration of all factors that arc welding will be extended to all types of fabrication without restriction.

Abridgment of

The Fundamental Plan of Power Supply of the Detroit Edison Company*

BY S. M. DEAN†

Member, A. I. E. E.

Synopsis.—*Experience indicates that if electric light and power systems are to expand indefinitely, without enormous obsolescence charges, a carefully coordinated engineering plan must be adopted and, so far as practicable, system extensions fitted to it. This paper sets forth the principles involved and the plan adopted by the Detroit Edison Company.*

The description of the area served and the classification of customers indicates that the system is essentially of the metropolitan substation type supplemented by a 120-kv. transmission system.

The importance of selecting proper circuit voltages and arrangements and their bearing on service reliability, system simplicity, and cost is discussed.

The underlying principles and the "Loose Linked" Power Area Plan adopted to accomplish those principles are set forth. These are supplemented by the plan for short circuit and stability control and the resultant classification of substations, power sources, and protection schemes.

Those characteristics of major electrical equipment affected by the plan are outlined.

Operating procedure and results are given.

I. Service Requirements

THE territory served by the Detroit Edison Company comprises 4400 sq. mi. in the southeastern part of the State of Michigan with a population of 2,190,000 people. The east central portion of the area is the city of Detroit, which comprises some 2 per cent of the areas served, but in which are concentrated 76 per cent of the people and 80 per cent of the power requirements.

For purposes of studying the electrical load requirements, the city of Detroit may be divided into three classes of districts:

1. The general business and commercial area which shows an average load density of 25,000 kv-a. per sq. mi.

2. Industrial areas having an average load density of 17,000 kv-a. per sq. mi.

3. The residential districts which fill in the gaps between the downtown commercial area and the indus-

†Senior Engineer, Engineering Division of the Detroit Edison Company, Detroit, Mich.

*Part II of a Symposium on Power System Planning.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930. Complete copy upon request.

trial districts in the outskirts of the city and which extend beyond into suburban or country areas. Load densities vary.

The system peak load is about 550,000 kw., and the output of the power plants on the order of 2½ billion kw-hr. per year. The entire system area lies within the same time zone. Half of the energy is delivered to less than 500 very large industrial and commercial power customers ranging in size from 100 to 15,000 kv-a. whereas only 12 per cent of the energy is delivered to 450,000 residence customers.

It is evident at once that an electrical system to serve such a territory will be essentially a substation system by reason of the many large industrial customers and the large proportion of low-density residential and commercial area which can be served well by overhead lines. Since most of its load lies within the city area, it will be in large part a metropolitan underground system. Also, since power plants are of necessity located along the waterways on the edge of the territory served, and there are relatively large blocks of load located some distance from them it will be, in part, a transmission system.

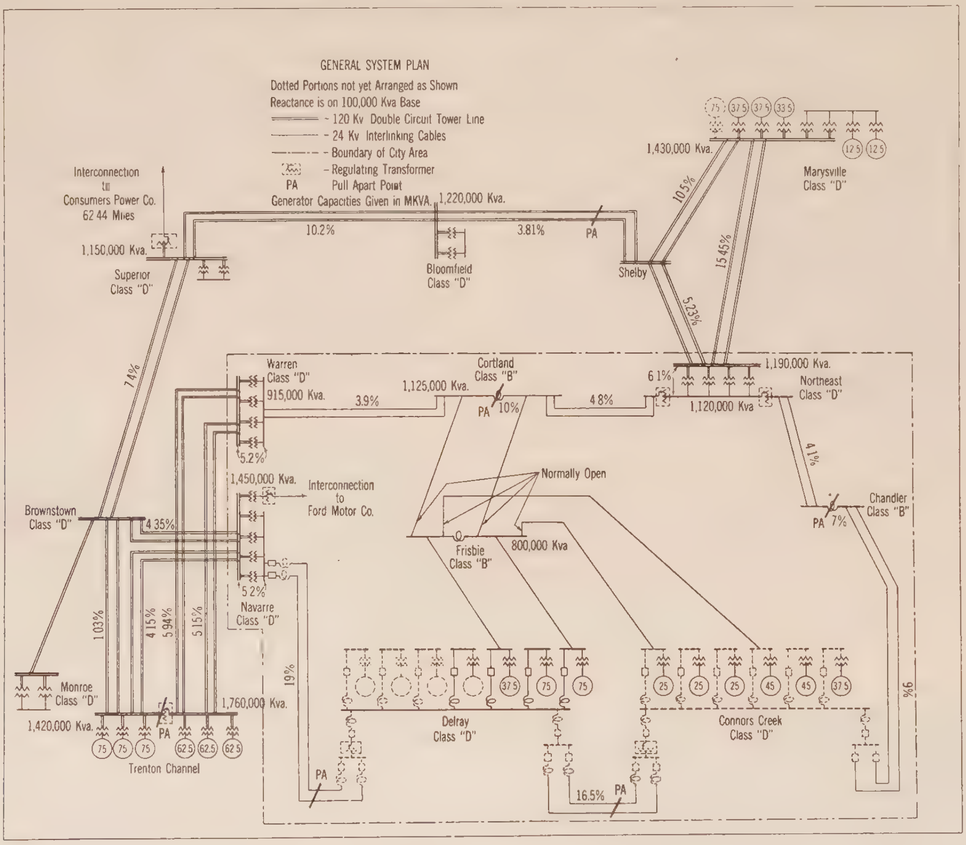

Fig. 2—General System Plan

II. Voltages

A 4800-volt three-phase *isolated neutral system* was early selected for distribution to industrial customers and was later extended to serve residential and commercial lighting customers. That voltage is sufficiently high for overhead distribution densities likely to be encountered for some time to come, and in the underground areas is quite adequate for customers up to 10,000-kw. demand or more. It is also low enough to be reasonably safe for overhead construction in streets and alleys and switchgear and regulating requirements are not burdensome. Also, grounds do not usually cause short circuits. This is most important from the service point of view.

A 24,000-volt, solidly-grounded neutral system is employed to feed substations, 24,000 volts being selected as low enough to be safe for the three-conductor cables used within the city, and high enough to serve reasonably the outlying substations through overhead lines. That voltage is also high enough to serve for some time to come any probable power requirements over any distances likely to be encountered in the underground district. It is also high enough to permit the transfer of large blocks of power between generating centers by operating a reasonable number of cables in parallel (see Fig. 2). This eliminates for some time to come the necessity for a higher voltage step for bulk power transfer underground.

The two generating plants located within the city load area (Delray and Connors Creek) deliver energy at 24,000 volts.

For the two generating stations more remotely located from their load areas (Marysville and Trenton Channel)

120-kv. solidly-grounded neutral transmission is employed. This transmission system also forms as a backbone for the outlying portion of the area served. Again, this voltage is sufficiently high to give convenient bulk transfer of power, both within the system and for interconnections. Fig. 2 illustrates the general transmission layout.

III. Fundamental Plan

Principles. The underlying principles which served as guides in the Detroit Edison Company's system plan are as follows:

1. It is neither necessary nor advisable to operate the Detroit Edison Company's electrical system as a single unit, but rather to operate it as a group of power areas, each served at 24,000 volts by its own powerhouse or large step-down substation.
2. Any acceptable system plan should be capable of indefinite expansion without recourse to major changes of switchgear or other electrical equipment; that is, without unreasonable obsolescence.
3. In order that it may be practically operative, the plan adopted must result in a simple system.
4. Substations and generating stations should be reduced to a minimum number of standard types and sizes employing, so far as conditions permit, equipment essentially standard with the electrical manufacturers.
5. Since the greater part of serious electrical operating troubles arises from the malfunction of switchgear or its accessories, it is good business and good engineering to eliminate (particularly on those parts of systems having grounded neutrals) as much switchgear, bus work, and accessories as possible.
6. So far as practicable, it is better to avoid the use of current limiting reactors in feeders, using them rather for sectionalizing purposes.

General Plan. The general plan which has been adopted to carry out the principles set forth is illustrated by Fig. 2. It consists of a number of 24-kv. generating stations, or 120-kv. step-down substations, (Class "D") each of which feeds what is termed a "power area."

Within the city, these Class "D" power sources are connected together by what we have termed "interlinking cables." These "interlinking cables" are so relayed that should an uncontrollable disturbance occur in any one of the step-down substations or generating stations or their connected 24-kv. cables, they will, as a last resort, open, leaving the power area in trouble to go its own way rather than unduly disturb the rest of the system. This is what is technically known as "loose linking." It is evident at once that those cables may be of any reasonable number and still be "loose linked;" that is, "loose linking" is a function of relaying and not of power transfer.

The "pull apart" points between power areas are essentially at the points marked *P A* on Fig. 2. The separation is accomplished by proper settings of the inverse time overcurrent "back-up" protection and gives sufficient time for first and second line defense relays to clear the fault, if that is possible.

In the suburban areas, the Class "D" power sources largely feed into a network of 24-kv. overhead lines, where short-circuit duty is a relatively simple problem.

With one exception, the control of voltage and wattless kv-a. between power areas is to be accomplished by tap-changing regulating transformers installed in the "interlinking cables" between power areas and between the halves of the 120-kv. bus at Trenton Channel. That exception is Northeast Substation (Class "D") where synchronous condensers are required because of the longer transmission distance.

It is evident at once that such a system can be extended indefinitely by connecting additional generating or step-down stations into the ring of "interlinking cables," provided the through impedance of the sections of "interlinking cables" between stations is kept up to

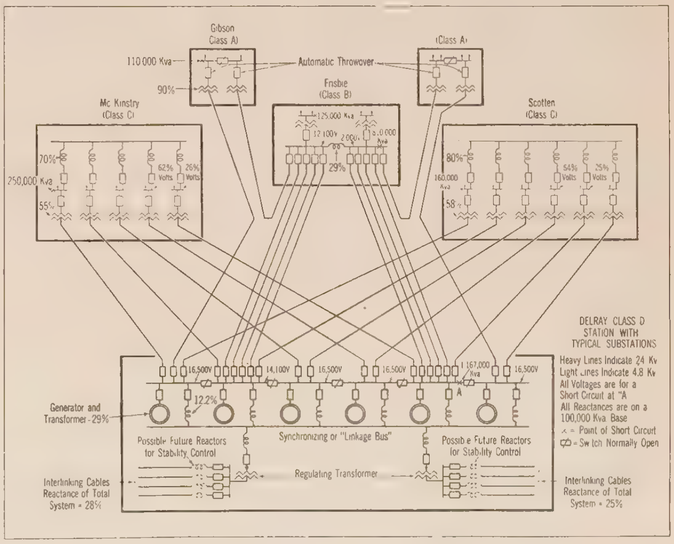

Fig. 3—Delray—Class D Station with Typical Substations

the same value. For this system the maximum value is approximately 20 per cent on 100,000 kv-a., which is reasonable from the standpoint of stability.

Short-Circuit Duty. After considerable study, the following criterion for short-circuit duty was adopted:

For 4800 volts—250,000 kv-a. maximum
" 24 kv. —1,250,000 kv-a. maximum
" 120 kv. —The nature of the 120-kv. system does not lend itself so readily to maximum short-circuit control, but it seems reasonable to assume that we can keep within 2,000,000 kv-a.

In arriving at these allowable short-circuit duties, it was necessary to take account of the types of generating stations and substations as well as the methods of interconnecting them. To meet those limits, and to reduce high-voltage switchgear to a minimum, the types of substations were adopted. (Fig. 3). The essential features of these types are as follows:

Class "A" Substations: They have no 24-kv. switchgear, they do not interconnect Class "D" power sources and they have *permanent maximum short-circuit duty* on the 4800-volt side.

Class "B" Substations: They serve as blocks of load which may be transferred from one power area to another as required, or may, as is usually the case be the connecting link between two power areas. They are so designed that, at a later date, they may be converted into points at which "bulk power" at high voltage may be fed into the 24-kv. system; that is, into Class "D" Substations.

Class "C" Substations: They have no 24-kv. switchgear, they do not interconnect Class "D" power sources, they have a *permanent maximum short-circuit duty on the 4800-volt side,* and by reason of their high "through impedance," they do not invalidate the generating station bus section reactors.

Class "D" Substations: In the 24-kv. generating stations sectionalizing reactance is required, and again the star-connected synchronizing or "equalizer" bus is employed. It is between these "equalizer" buses and the 24-kv. buses in the 120-kv. stepdown substations that the "interlinking cables" are connected.

The number of Class "B" switching stations is kept at a minmum as they do materially short-circuit the generating station bus section reactors. This also results in confining the costly and hazardous 24-kv. high-duty circuit breakers to the comparatively few Class "B" and Class "D" substations and *reducing the number to something like half those that would be required if 24 -kv. switching were used in all substations.* This is an important consideration from the point of view of reliability and economy.

Fig. 2 shows the distribution of reactance between power areas throughout the system.

Fig. 3 illustrates the combination of a power plant with typical substations and "interlinking cables." The interesting features of such a layout are the synchronizing or "linkage buses," the means of connecting the power area into the system, (note that this is done simply with standard 24-kv. cable and switchgear) *the reduced amount of 24-kv. switchgear and the total absence of duplicate 24-kv. busses and switching.* This absence of duplication is possible because each substation transformer in connected to a separate generating station bus section. It is possible, therefore, to lose any one generating station bus section without losing more than the normal reserve of feed to each substation.

The star-connected synchronizing bus was chosen because every generator or group of tie cables is made equally available to every other one, and power transfer between them can be accomplished with a minimum of voltage variation.

The star-connected synchronizing busses, with their reactors in the Class "C" Substations and the automatic throw-over equipment which permits straight radial operation of each transformer in the Class "A" Substations, are the devices by which short circuits are kept down on the 4800-volt system. Fig. 3 illustrates these arrangements.

The general use of Class "C" Substations with the transformers paralleled on the 4800-volt bus through reactors results in a much higher average short-circuit duty on the 4800-volt system than would be the case if the Class "B" substations were employed in which the 24-kv. bus eliminates the necessity for 4800-volt paralleling. This condition was deliberately chosen because it is very difficult to keep permanent control of short-circuit duty if 24-kv. switching is generally used. It is better in principle to have the higher short-circuit duty on the lower-voltage isolated-neutral system than on the high-voltage grounded-neutral system. The cost of suitable 4800-volt circuit breakers for this higher duty is not enough greater to be of ruling consideration. Operating experience over a period of years indicates almost no trouble from 4800-volt circuit breakers, and the actual high short-circuit duty area is relatively small.

Protection Schemes. The relaying methods adopted are as follows:

Instantaneous relaying for 120-kv. line faults. (Double-circuit tower lines relayed differentially. Single-line operation over-current, for lack of suitable faster method.)

Instantaneous relaying for 120-kv. transformers.

Inverse time over-current protection for 120-kv. bus faults and as "back up" protection for line faults (for lack of suitable faster method).

Instantaneous relaying for all 24-kv. line or cable faults over approximately 205,000 kv-a.

Instantaneous relaying for all 24-kv. transformers, if the fault is in the high-voltage winding.

Instantaneous relaying for all generators and their step-up transformers.

Inverse time over-current protection for 24-kv. bus faults in outdoor switching substations and also as "back up" protection for line faults. (For lack of suitable faster method).

Instantaneous fault bus relaying on all indoor 24-kv. switching substations.

Approximately ½ second inverse time delay on 4800-volt line faults which have 250,000-kv-a. ultimate maximum. (To permit transformer fuses and customers breakers to clear first).

Instantaneous bus differential relaying for all 4800-volt equalizer buses in Class "C" Substations.

With the exception of fault bus protection, each relay and method has been employed on the system for a number of years.

Stability. In arriving at any system general plan giving the desired distribution of reactance for proper

short-circuit control, the opposite horn of the dilemma must be faced in the form of stability under operating conditions and the final solution must be a balance between these two considerations.

In the system plan outlined above, dependence is largely placed on fast relaying and switching for protection against instability.

So far, stability studies have been confined largely to limiting cases of three-phase faults on major buses (both 120-kv. and 24-kv.). Three-phase faults, directly at the 120-kv. busses at Trenton Channel or Marysville generating plants theoretically approach instability in the case of some of the older and slower circuit breakers. However, taking account of the difference between the theoretical and the actual operating conditions, and the fact that for several years we have operated the 120-kv. system under essentially the present conditions without any evidence of instability, there is reason to feel that the situation is satisfactory.

All studies so far made indicate that there is a reasonable margin of safety in the case of the 24-kv. system,—even under three-phase fault conditions.

IV. Equipment Characteristics

The characteristics of equipment are determined to varying degrees by the general type of system employed. The essential equipment characteristics as determined for this system are as follows:

Prime Movers. The last nine turbo generator units have been designed with a nominal rating of 50,000 kw., a best point rating of 43,000 kw., and with good vacuum conditions and extraction, could probably carry somewhat over their nominal ratings. A plant group of six units can be loaded on average days to 250,000 kw. with maximum economy, with one unit down, it can still carry 250,000 kw. reasonably, and, if necessary, care for somewhat greater short time peaks. With two units down, it can carry somewhat over 200,000 kw. Such a plant has an excellent running reserve and requires a minimum of transfer lines and cables.

Generators. All generators whose output is at 24-kv. or 120-kv. have the generators and step-up transformers arranged as a unit. The reactance of the combined generator and transformers is kept at from 20 to 25 per cent. So far no trouble has been experienced due to instability of machines under suddenly applied loads, and therefore no particular short-circuit ratio has been specified.

Excitation System. Hand-controlled excitation by means of throttled pole exciters without main generator field rheostats, has been employed so far with entire satisfaction.

Circuit Breakers. The following speeds of operation and interrupting duties are required.

Service	Time	Rating
120-kv.	15 cycles	2 million kv-a.
24-kv.	10 cycles	1¼ million kv-a.
24-kv.	10 cycles	½ million kv-a.
4800-volt	7 cycles	250,000 kv-a.
4800-volt	7 cycles	150,000 kv-a.

The above circuit-breaker times are from the energizing of the trip coil to the parting of contacts on a 60-cycle basis.

V. Interconnections

The company has four interconnections and two throw-over fringe connections.

The interconnection with the Consumers Power Company was made to profit by the diversity between the combined hydraulic-steam system of that company and the all-steam system of the Detroit Edison Company, and for mutual reserve.

The interconnection with the Ford Motor Company is for mutual reserve. The initial installation of 30,000-kv-a. capacity has been operating for a few months and the second installation of the same capacity will shortly be made.

Interconnections are also established with the University of Michigan and the Packard Motor Car Company to equalize steam heating load and power requirements.

Two throw-over fringe connections have been established with the Consumers Power Company along the mutual boundary line at points too remote for duplicate feeds.

VI. Operating Procedure

Load control is accomplished by the load dispatcher assigning to three of the four power plants a definite load as determined by plant economy and instructing the fourth plant to hold frequency.

Frequency control is manual and the Warren Clock Method of indication is employed as a guide.

The general rule is that sufficient running reserve is maintained at all times to permit dropping the largest machine in any one plant on the system. Even with one machine down for overhauling, the plant must be able to carry its own load if it loses a second machine or loses its ties with one neighboring power area, thus meeting the requirement of the general rule. If there is sufficient machine or tie capacity to meet this condition, no change need be made in the power area; but if not, then the boundary of the power area must be adjusted to meet the new conditions.

VII. Results as Determined by Operating Experience

The 120-kv. system has been operating in essentially the form shown in the plan for about a year and has given entire satisfaction. During that period, faults have been confined to the lines.

The first of the 24-kv. Class "D" power plants has just gone into commission and as yet no experience has

been obtained. It is the Delray Plant shown in Fig. 2.

Quite a number of Class "A" and Class "C" Substations has been in commission a year or more and during that time has functioned under line faults, giving very satisfactory results.

The 120-kv. step-down substations (Class "D") have been in satisfactory operation a number of years.

The performance of 4800-volt equipment under fault conditions has given full satisfaction.

ACKNOWLEDGMENT

The writer wishes to express his appreciation of the valuable suggestions and assistance given by Messrs. R. E. Green and I. S. Mendenhall in the preparation of this paper.

Acoustics of Radio Broadcasting Studios

BY L. E. VOORHEES[1]

Non-member

THE advent of radio broadcasting as a new kind of entertainment in the early part of 1920 immediately created a need for radio broadcasting studios. The development of the broadcasting studio during the four years following its creation has been just as rapid as the development of radio transmitting equipment because of its importance to the proper functioning of the radio broadcasting system.

The broadcasting studio should provide the ideal place where addresses and musical programs can be given and picked up by the radio microphone. This does not mean that radio pick-ups cannot be made satisfactorily at other places. In determining the location of the studio, particular attention should be given to minimum street and building noise and facilities for connecting the studio electrically with the transmitting station. The development of high quality telephone circuits for transmission of speech and musical sounds over long distances with very little distortion has made it possible to locate the studio a great distance from the transmitting station if desired, and also to connect the studio with any number of broadcasting stations throughout the country.

The first requirement of an acceptable broadcasting studio is that it should be as acoustically perfect as possible. The degree of acoustic perfection actually obtained is determined by the quality of the material picked up by the microphone in the studio. Judging the quality of a performance in a studio by means of the human organs of hearing will not give satisfactory results because these organs are too highly selective. The human organs of hearing are accustomed to function in places where a great many sounds and noises are mixed together in a complex manner and for this reason they are trained to concentrate on those sounds which the person desires to hear and suppress those sounds which the person does not desire to hear. The radio microphone which is the organ of hearing for the broadcasting system does not possess this mental property of selectivity which the human organs of hearing do and, therefore, it picks up all sounds and noises in their true relation to each other. For this reason a studio acoustcially correct for microphone pick-up work will not be acoustically correct for the human ear. When one enters an acoustically correct studio for the first time this effect is manifest by the "dead" condition of the room which the person experiences while talking. To people not accustomed to broadcasting from studios, the absence of familiar side tone, so to speak, is very disconcerting at first. This condition as a rule causes the performer to increase the volume of his voice, or if a musical instrument is being played, to play with more vigor. The added volume is unnecessary from the standpoint of the microphone, the result being a possible overloading of this instrument. The above phenomenon illustrates why the human organs of hearing cannot be relied upon as a standard for judging the quality of material produced in a broadcasting studio.

When the demand for broadcasting stations became a fact, the need for acoustic information from all established sources was increasingly great. Engineers who undertook to perfect the radio studio in the early days of its development naturally turned their attention to the results obtained in the field of acoustic correction of buildings by such men as Professor Wallace C. Sabine of Harvard University and Professor Floyde R. Watson of the University of Illinois. Professor Sabine's pioneer work in the field of acoustics of buildings dates back to 1895 and it was due to his early experimental work that many of the underlying principles of acoustics were established. Professor Watson's work which is admirably described in his book on "Acoustics of Buildings," published in 1923, was written for the purpose of furnishing information which would be helpful in advancing the development of acceptable acoustics in buildings with a view to aiding architects engaged in the design of new buildings to avoid acoustic defects.

The greatest difficulty experienced by the engineers designing broadcasting studios was that all the material available on the acoustic correction of buildings was obtained on the basis of making the buildings acceptable to the human organs of hearing, while the material desired was for the purpose of making a broadcasting studio acceptable to a very unhuman and more exacting electrical organ of hearing known as the microphone. It can be seen, therefore, that the acoustic correction of broadcasting studios was in this respect an entirely new scientific investigation for an entirely different purpose. However, a large amount of valuable infor-

1. Radio Engineer, Washington, D. C.

mation was obtained from the work done by investigators along the lines of acoustics of buildings which played no little part in the advance of the art of radio broadcasting. For example: The coefficients of absorption for various materials as established by Professors Sabine, Watson, and others and the theoretical principles underlying their use have been used extensively in the acoustic correction of studios.

It is the purpose of this article to give a general picture of the methods that engineers have used in constructing acceptable broadcasting studios without going into too much detail. This paper would be incomplete, however, without a brief review of the nature of sound and its behavior in a closed room.

Sound is a form of energy. Energy cannot be destroyed but it can be transformed from one kind into another. For example; if a sound wave in the air strikes against a board with a knot-hole in it, part of it may be changed into mechanical energy which vibrates the board, part may pass through the knot-hole and be lost, while the remainder may be changed into heat energy due to the friction between the air particles and the particles of wood as the sound wave passes through the board or is reflected from the surface of the board. A sound wave consists of a series of compressions and rarefactions produced in solid, liquid, or gaseous material by a vibrating body. The waves proceed away from the source in all directions, the zones of compressions and rarefactions forming spheres having for their centers the source of the sound until they strike some interfering medium which may change the wave form of these spheres.

Whenever sound waves pass from one medium into a second medium with different density or elasticity, they undergo a change. Part of the energy is absorbed in the form of heat and mechanical energy by the second medium, part is transmitted through the second medium, and part is reflected back from the surface of the second medium; the relative amounts in each case depending on the difference in density or elasticity between the two media.

Sound waves are propagated through a medium with a velocity V which depends upon the elasticity E and the density d of the medium according to the following formula:

$$V = \sqrt{E/d}$$

Table I[2] gives values of sound velocities for a few media.

TABLE I
VELOCITY OF SOUND IN VARIOUS MEDIA

Medium	Velocity of sound
Air..................	1,088 ft. per second
Water...............	4,728 " " "
Pine wood...........	10,900 " " "
Brick................	11,980 " " "
Steel................	16,360 " " "

2. Smithsonian Tables—Tables 80 and 81.

An inspection of these data shows that sound travels much slower in air than it does in liquids or solids.

Certain materials, like hair felt, carpets and draperies, present very little resistance to the propagation of sound waves. The reflection from the surface of this material is not large but the absorption of the sound energy in the openings between the fibers of this kind of material may be quite large. That part of the sound which is not reflected or absorbed passes through the pores of the material. If sound comes in contact with a smooth, non-porous, rigid surface, like a highly polished plaster or marble wall, most of the sound will be reflected back into the room and very little will be absorbed or transmitted. Sounds generated in solid materials are usually confined to those materials, except for cases where the materials vibrate with sufficient magnitude to produce condensations and rarefactions in the surrounding air. The reverse of this process takes place when a sound produced in the air has a frequency of the order of that which a solid body would have if left to vibrate free from any interference. In this case, the solid body is set in motion by the sound wave, and the vibrations in the air and in the solid body are said to be sympathetic or in resonance with each other. Two vibrating solid bodies may be in resonance with each other at a certain frequency of vibration.

It can be seen, therefore, that the absorption or sound which is the prime factor entering into the acoustic correction of broadcasting studios is due mainly to friction which occurs between the walls of the interstices in the absorbing material and the oscillating air particles which converts the wave energy into heat energy. The absorption and the transmission of sound varies with the thickness of the absorbing material not in direct proportion but according to the exponential law:[3]

$$i = i_o a^{x}$$

where i and i_o are the intensities of the sound that enters and is transmitted by the material respectively, a is a constant depending on the kind of material used, and x is the thickness of the material.

I have given this rather brief resumé of the nature of sound as a background for the following discussion on the behavior of sound in a broadcasting studio.

When a speaker makes an address before a microphone in a broadcasting studio, the sounds he utters proceed away from the source in all directions until they strike the boundaries of the studio or objects located in the studio. Here they are reflected, transmitted and absorbed in varying amounts depending upon the physical character of the objects and walls with which they come in contact. The reflected sound again travels about the room in directions determined by the laws of reflection until it again comes in contact with objects whose density and elasticity is greater than

3. F. R. Watson "Acoustics of Buildings," p. 4.

air and then suffers a second loss of energy due to absorption or transmission through the walls of the studio. Since sound travels in air with a velocity of about 1088 ft. per second at ordinary temperatures, it will readily be seen that due to successive reflections it rapidly fills the studio. However, at each reflection the intensity, and hence the total energy of the wave, has been diminished with the result that it gradually dies out. Since the sound is so rapidly reflected about the studio, the intensity or loudness at any instant is the same in all parts of the studio. At first thought it would appear that it would not make any difference in what part of the studio one placed the microphone. This is true from the standpoint of the intensity of the sound acting on its diaphragm but reflection has its ill effects as well as its good ones.

Reflection produces a prolongation or reverberation, as it is called, of the sound and this is the most serious and common defect experienced in broadcasting studios and therefore requires first consideration. In this respect, speech differs widely from sustained musical sounds. Speech sounds are of such short duration that their amplitude, that is, magnitude of the waves produced by them, is small and hence they are usually absorbed rapidly after few reflections. Sounds of this nature build up to maximum volume and die down to zero volume very rapidly; therefore they do not persist for very long intervals of time in the studio. Sustained musical sounds, however, have to undergo many more reflections than speech sounds would to diminish them to zero volume and for this reason, they persist for a much longer interval of time.

Another result of the reflection of sound is called interference. Sound waves reflected from the walls and objects in the studio may meet succeeding oncoming waves in the proper phase relation to produce concentration at certain points and total or partial interference at other points. These points of concentration and interference depend upon the frequency of the sound. In the case of musical sounds this effect can be noted when certain sounds are augmented while others are weakened or remain normal. Because of their short duration, speech sounds do not manifest this effect to any marked degree.

Let us suppose that a sound wave comes in contact with an elastic body which is more or less free to move. As I have mentioned before, if the natural or free period of vibration of the elastic body is of the order of frequency of the impinging sound, a condition of resonance is established and the body or wall vibrates in tune with the sound producing the vibration. Resonance, therefore, has a tendency to increase the volume of the sound producing it.

If one stands in front of a distant building and claps his hands, he will note that the sound returns to him in a short time after reflection from the building. This reflection which is in no way distorted is called echo. Echoes are not so troublesome in small broadcasting studios as they are in large auditoriums. Echoes are annoying, however, when they do occur, and can be eliminated or greatly reduced by either changing the shape of the reflecting surface in order to break up the sound or by making the surface more absorbent thereby reducing the reflection.

When several musical instruments are being played or a quartette is singing in a studio, any augmenting or diminishing of certain tones alone, produces a very disagreeable, unnatural combination of sounds which we term distortion. The microphone is sensitive to every sound and does not filter out undesirable ones like the human organs of hearing do by mental processes. In order to obtain a faithful reproduction of studio entertainment we must first produce it correctly. There are two important factors which, if properly controlled, will give us studio material which will be scientifically acceptable for pick-up by the microphone. These factors are, first, an acoustically correct studio and second, proper arrangement of the artists and instruments in the studio.

What is meant by a studio acoustically correct for broadcasting? Professor Watson says,[4] "Perfect acoustic conditions in an auditorium are obtained when an average sound rises to a suitable intensity in every part of the room with no echoes or distortion of the original sound, and then dies out quickly enough not to interfere with succeeding sounds."

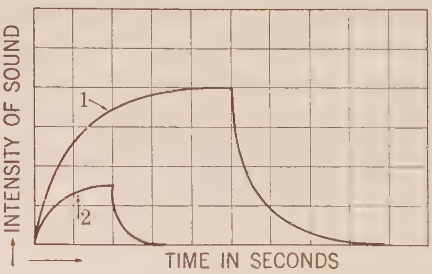

FIG. 1

Professor Watson's answer to the question as applied to auditoriums replies equally well to the question as applied to broadcasting studios.

Fig. 1 shows graphically how a sound grows to a maximum and then decreases, before and after a studio has received acoustic treatment.

Curve No. 1 is for a studio with small absorption and shows how the sound intensity grows slowly to a maximum and after being stopped, decays slowly to zero. Curve No. 2 is for this same studio after it has been corrected and has large absorption. It will be noted that the growth and decay is very rapid in this case. It will also be noted from the curves that placing absorbing material in the studio materially reduces the intensity. According to the law of conservation of energy, you cannot get something for nothing; therefore, you cannot obtain a perfect acoustic condition

4. F. R. Watson's "Acoustics of Buildings," p. 11.

in a studio without incurring some loss in the volume of the sounds produced therein after treatment. This, however, is a fortunate loss in the case of broadcasting studios since large volume is not required for microphone pick-up work. This leads us to the discussion of the acceptable size of a studio with respect to the source of sound.

Good acoustics and correct reproduction, as determined by means of the microphone as an electrical ear, have been obtained in many of the broadcasting studies throughout the country. By increasing the volume of music in such studios to the point where the quality just begins to become imperfect and then plotting these limiting energies against the volume of the studios in cubic feet, respectively, a curve would be obtained showing the relation between the energy of sound and the volume of the studio. This curve would be an approximate guide in determining what size orchestra or group of singers could perform satisfactorily in a studio of a given size. The number of different kinds of instruments for best effect can be determined in the same way. It has been found by experience that studios used principally for musical programs should be larger than those used for addresses. An address can be made from an acoustically treated telephone booth with just as good and sometimes even better results than if made from a small studio. For esthetic and hygienic reasons, small booths are not used extensively for this type of broadcasting although they are used for announcing purposes in places where there is considerable noise and confusion between various parts of a program. For orchestras of approximately 10 pieces, the studio should have a volume of about 8000 cu. ft. to give best results. Such orchestras should contain very few brass instruments. For larger orchestras having a greater number of brass instruments, larger studios should be provided. No sharply defined limits can be placed on the size of the studio for volume of music produced, and for this reason, the results obtained in actual cases are the best criteria.

The most important phase of the subject of acoustics of broadcasting studios is the correction of excessive reverberation. This defect has been touched upon briefly in a preceding part of this paper. Let us assume that we have a steady source of sound in a studio. Sound waves will proceed away from this source in all directions and come in contact with the boundaries of the studio and various objects in the studio, where part of the energy will be absorbed at each reflection. In a short time a state of equilibrium will be reached when the quantity of energy absorbed will equal that which is being generated. If the source of sound is stopped suddenly, the sound in the studio will die out. The time that it takes the sound to die out will depend on the absorbing power of the walls, furniture, draperies, etc., in the studio.

Professor Sabine developed the following formula for the energy of sound per unit volume:

$$E = \left[\frac{A\,P_e}{a\,v\,V} \right]^{-\frac{a\,v}{p}t}$$

Where:
E = energy of the sound per unit volume
A = sound energy emitted per second from the source
p = mean free path between two reflections
a = average absorption coefficient
V = volume of the room
t = time
v = velocity of the sound.

After Sabine developed his formula, G. Jager, of Vienna, developed a similar formula which is as follows:

$$E = \left[\frac{4\,A}{a\,s\,v}\, e \right]^{-\frac{a\,v\,s}{4\,V}t}$$

where the quantities are the same as in Sabine's formula with the additional quantity s representing the surface area of all the objects exposed to the action of the sound and the quantity p omitted. A study of the above formulas shows several interesting facts. If the source of sound A is kept constant, the maximum intensity which the sound can reach depends on the term $a\,s$ in the factor $\frac{4\,A}{a\,v\,s}$. When $a\,s$ increases, the intensity decreases, $a\,s$ representing the absorption factor in the equation. As the size of the studio is increased, the term $a\,s$ is increased and the volume of the sound is correspondingly decreased. Speech sounds which have short duration would not apply in this case since it is assumed that the source of sound persists long enough to reach the state of equilibrium in the studio. Where there are several kinds of absorbing materials in the studio, each having its own value for the term $a\,s$, then the term used in the equation for absorption will be the summation of all the individual absorption terms.

The reverberation or decay of the sound in the studio is given by the expression:

$$e^{-\frac{a\,s\,v\,t}{4\,V}}$$

For the best acoustic condition the value of t should be small and the value, therefore, of the factor $\frac{a\,s\,v}{4\,V}$ proportionately large. Since the volume V of the average studio is small, t should be correspondingly small for good acoustics. If t is not small, absorbing materials must be introduced into the studio to reduce the reverberation or "liveness" as it is called. Too much absorbing material will make the studio too "dead," and too little material will make it too "alive." These two expressions have come into general use for acoustic engineers.

For musical performances, a studio should not be too "dead" since there are usually a number of persons

performing and the microphone cannot be placed too close to the performers and still be in the best location to pick up a balanced combination of tones from the various performers. For addresses, the speaker is located directly in front of the microphone within the limits of 6 in. to about 3½ ft. and in this case only the direct sound from the speaker is desired. No reflected sound is necessary and therefore the studio used for this purpose could never be considered too "dead." If the speaker's studio is extremely dead, it is difficult at first for the speaker to adjust his organs of hearing, which are not accustomed to these conditions, so that he will not be tempted to shout into the microphone in order to produce enough side tone in the studio to satisfy the requirements for ordinary hearing. Shouting into the microphone is just as disastrous to the quality of the output of this instrument as talking too low. When a speaker is located more than 3½ ft. from the microphone in a "dead" studio his voice will sound hollow or metallic. This defect is due to the absence of low pitch tones and overtones in the speakers voice. The effect is explained as follows: In a "dead" studio the low pitch sounds are absorbed more readily than the high pitch sounds. High pitch sounds, therefore, predominate in the total reflected sound existing in the studio at any instant. When the speaker is close to the microphone, its diaphragm is actuated primarily by the direct sound. The reflected sound has very little effect. As the speaker moves away from the microphone, the intensity of the direct sound received at the diaphragm becomes smaller and the intensity of the reflected sound, which is predominately high pitched, greater in proportion. The result is an increase in high pitch sounds with a decrease in low pitch sounds which makes the speakers voice sound hollow. In the case of pick-up work in "live" studios or out of doors the reflected sound reaching the microphone does not contain an excess of high pitch sound to so great an extent and, therefore, the speaker can talk at greater distances from the microphone than he can in a "dead" studio. If the speaker's voice is strong and rich in low tones, this hollow, metallic effect is not so pronounced. This explains the reason why some voices, rich in overtones, broadcast better than others which are of high pitch and staccato.

Fig. 2 shows two curves obtained by plotting the time of reverberation against the volume of the room where the acoustics of the room are maintained for best results. Curve No. 1 is Watson's Curve[5] for music rooms with maximum audiences. Curve No. 2 is for broadcasting studios with only the performers present. The data for both these curves were obtained from actual tests made in music halls and broadcasting studios of various sizes. In the case of the studio, of course, the audience is not a factor for consideration. As mentioned before, music halls and auditoriums are designed to satisfy the organs of hearing of the audiences, while broadcasting studios are designed to satisfy the requirements of the microphone. Examination of the two curves shows that the time of reverberation for studios is less than that for music halls having the same volume. For instance, a concert hall of 8000 cu. ft. should have a reverberation of 0.80 sec. with maximum audience for good acoustics, while a broadcasting studio used for music and only the performers present, should have a reverberation constant of 0.64 sec. For addresses the studio should have a constant of 0.45 sec. or less.

Radio broadcasting studios have a decided advantage over music halls in that the reverberation can be varied to a great extent in order to compensate for the number of persons present. This is accomplished by providing mechanical means for shifting the absorbing material which is hung against the plaster walls of broadcasting studios so that this material can be bunched together at certain points, thereby exposing a considerable part of the hard plaster surface to the sound, making the studio more "alive." Although the same amount of material remains in the studio, its increased absorbing power when massed together is more than offset by the increase in reflection from the exposed plaster wall;

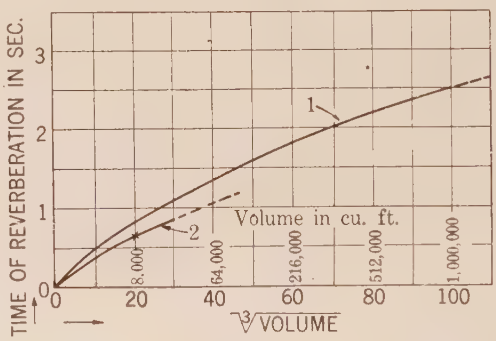

Fig. 2

hence, the time of reverberation is increased by this method. People make good absorbing material. When a studio is found to be too "alive" after all means available in the studio for reducing the reverberation have been utilized, the introduction of a few of the people from the reception room into the studio will generally add enough absorbing material to correct the defect. In auditoriums where a variable audience forms part of the absorbing material, wider limits have to be accepted for the time allowable for reverberation.

The absorbing materials used to correct the reverberation and other defects in broadcasting studios are with few exceptions identical with those used in the acoustic correction of buildings. Again the progress in the art of acoustic correction of buildings has materially helped to advance the perfection of radio broadcasting studios. Many materials have been tested by means of sensitive sound measuring instruments, such as the resonator developed by Lord Raleigh, and the values for the absorption power determined most accurately. A very common material used in broadcasting studios is hair felt about 1 in. thick. This felt is secured firmly to the

5. F. R. Watson's "Acoustics of Buildings," p. 30.

surface to be treated. A membrane of loosely woven cloth, such as crash, is stretched at a distance of about 1 in. from the hair felt. This membrane can be obtained in colors to correspond to the interior decorations. In some cases it has been tinted in various designs, although this is not desirable from the standpoint of absorption power as the material used for tinting fills the pores in the membrane which obstructs the passage of sound waves through it. An unpainted membrane effectively hides the hair felt but permits the free passage of sound to the highly absorbing felt. As sounds pass through thick material of this nature, absorption takes place before it reaches the hard surface in the rear and again after the sound has been reflected. Thick materials act as good sound absorbers. The hair felt treatment is usually applied to the ceilngs of studios, the side walls being treated with heavy adjustable draperies extending from the ceiling to the floor. Heavy carpets on the floor prevent reflection from this source and are very effective in reducing the reverberation in the studio. Overstuffed furniture is another excellent sound absorbing material.

Table II[6] gives some of the coefficients of absorption obtained for different materials by F. R. Watson. The list of materials is being enlarged every year so one ought to have no difficulty in selecting the right material for the right purpose.

The arrangement of the pieces of an orchestra or the different voices of a group of singers with respect to the location of the microphone is a very vital problem when good quality is to be produced. The microphone's diaphragm is not so sensitive to the low pitch sounds produced by bass instruments and bass voices as it is to high pitch sounds. Low pitch instruments located in the vicinity of absorbing material may have the greater part of their sound energy absorbed before it has an opportunity to be reflected about the studio. For these reasons bass voices and bass instruments are located close to the microphone while the other instruments or voices are located at distances proportional to their pitch and the intensity of the sound produced by them. Large volume is not required in studio work because special high quality vacuum-tube amplifiers are employed for increasıng the volume output of the microphone to the proper energy level. Every effort should be made to secure the best balance between the various sources of sound in a studio without distortion, so that the material leaving the studio as electrical energy, when transformed back into sound energy, will approach as nearly as possible an exact reproduction of the performance that the musical director intended to produce. One cannot judge, therefore, the quality of entertainment leaving a studio by merely listening to it in the studio because, as said before, the studio is designed to function with respect to the microphone, which is an entirely different organ of hearing then the human organs.

6. Watson "Acoustics of Buildings," page 25.

Some of the broadcasting stations operate a group of one or more studios with a separate acoustically treated room in which a high quality loudspeaker is installed for monitoring. In such rooms the quality is judged and changes in studio arrangements are suggested on the basis of the conclusions reached. Monitoring rooms are generally used most during tryouts; however, some broadcasting stations provide for continuous monitoring during the broadcasting period.

Table II

Sound Absorption Coefficients

Akoustolith (artificial stone) Per sq. ft.	0.36
Brick wall, 18 in. thick	0.032
Brick wall, painted	0.017
Brick, set in Portland Cement	0.025
Carpets, unlined	0.15
Carpets, lined	0.20
Carpets, heavy with lining	0.25
Carpet rugs	0.20
Celotex, ½ in. thick	0.31
Cheese-cloth	0.019
Coca matting, lined	0.17
Concrete	0.015
Cork tile	0.03
Cretonne cloth	0.15
Curtains, chenille	0.23
Curtains, in heavy folds	0.5 to 1.0
Flax, 1 in. thick, with unpainted membrane	0.55
Glass, single thickness	0.027
Hair felt, 1 in. thick, with unpainted membrane	0.55
Hair felt, 1 in. thick with painted membrane	0.25 to 0.45
Hair felt, 2 in. thick with unpainted membrane	0.70
Hair felt, 2 in. thick, with painted membrane	0.40 to 0.60
Insulite, ½ in. thick	0.31
Linoleum	0.03
Marble	0.01
Oil paintings, including frames	0.28
Open window	1.00
Oriental rugs, extra heavy	0.29
Plaster on wood lath	0.034
Plaster on wire lath	0.033
Plaster on tile	0.025
Stage opening, depending on stage furnishing	0.25 to 0.40
Varnished wood	0.03
Ventilators, (50 per cent open space)	0.50
Wood sheathing	0.061
Wood, varnished	0.03
Individual Objects	
Audience, per person	4.7
Church pews, per seat	0.2
House plants, per cu. ft	0.0031
Seats, upholstered, depending on material and lining	1.0 to 2.5
Seats, cushions, cotton covered with corduroy	2.16
Seat cushions, hair covered with canvas and light damask	2.27
Settees, upholstered in hair and leather, seat and back	3.
Wood seats, for auditoriums	0.100

The walls of broadcasting studios are often con-

structed of a semi-hard material to which plaster is applied. Where several studios are grouped together, the walls between them are sometimes "Floated." A floating wall is one which has no rigid connection with the other walls of the building, the rigid members of the floating wall being separated from those of adjacent walls by a loose material which acts as a cushion. A floating wall greatly reduces the amount of sound transmitted from one studio to another as a result of vibrations set up within the rigid portion of the wall itself.

Broadcasting studios which have windows opening on noisy streets are unable to obtain satisfactory results when it is necessary to open the windows for ventilation. A studio constructed in the interior of a building without windows is much to be preferred from the standpoint of interfering noise, but special attention must be given to the acoustic treatment of the air ducts used for forced ventilation of such studios. Where several studios are fed from the same ventilating

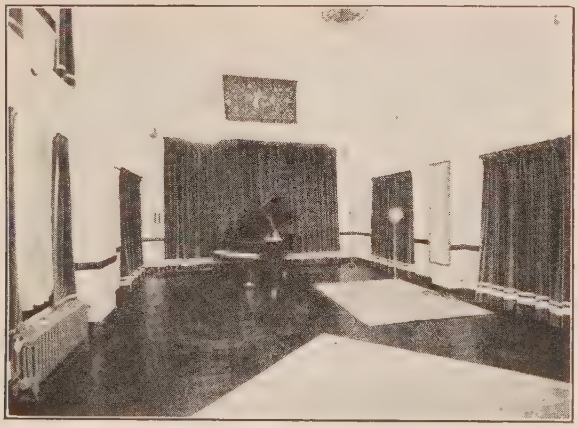

Fig. 3—Large Studios of the Washington Studios of the National Broadcasting Company

system and two or more are being used simultaneously, as is the case at some of the larger broadcasting stations, the air ducts connecting the various studios would act like speaking tubes and convey the sound from one studio to another. Ventilating systems for broadcasting studios therefore have to be designed from the standpoint of good acoustics in addition to that of providing fresh air. This is accomplished by lining the separate channels leading from the fan to the studios with hair felt or other absorbing materials. The length of these air channels must be such that all the sound leaving one studio by this means will be absorbed before it has an opportunity to reach another studio. To aid the absorption process and provide the most indirect path for the sound, a number of bends are formed in the air ducts. These bends, lined with absorbing material, offer very high resistance to the passage of sound, and not a great additional resistance to the slow moving air streams. As has been pointed out, metal is a good carrier of sound vibration. For this reason the metal air ducts coming from studios are acoustically separated from the main entrance to the blower by a canvas tube. In this way vibrations set up in the movable parts of the blower are prevented from passing through the metal which forms the air ducts into the studios.

Figs. 3 and 3A is a typical studio and Fig. 4, a typical

Fig. 3A—Small Studio of the Washington Studios of the National Broadcasting Company

studio used primarily for addresses. The draperies on the side walls can be so adjusted as to expose the plaster wall if necessary. Both studios have false ceilings of cloth which hides the absorbing material mounted on the hard plaster. The ventilator openings are located behind the side wall draperies. A heavily padded monitoring room is located between the two studios

Fig. 4—Studios for Addresses

fitted with double glass windows for observation. The walls of this monitoring room are floated so as to prevent transmission of sound into the room from the studios by means of vibrations set up in the walls.

The facts discussed in this paper should make it clear that the design of an acoustically correct broadcasting studio is not a matter of guess work but is a result of the analysis of the acoustic properties of the

materials entering into the construction and decoration of the studio and the application of mathematical formulas in order to secure the proper size and reverberation constant for the best acoustic conditions. The studios of Stations WEAF and WJZ, New York City, are good examples of studios for which careful acoustic calculations were made, and the corrections which were necessary determined before the actual construction began. Only minor acoustic changes were necessary after these studios were completed. These were excellent examples of the accuracy which can be obtained through the intelligent application of existing acoustic data to the design of acceptable radio broadcasting studios.

Abridgment of

Submarine Telegraphy in the Post War Decade

BY L. S. COGGESHALL*

Non-member

Synopsis.—*The post-war decade, which has given to the technique of the submarine telegraph both the regenerative repeater and the inductively loaded cable, deserves to be chronicled as one of the most significant periods in the history of the cable art. These two major developments, and some important corollary inventions and applications, are discussed in this paper. Reference is made to articles previously published describing recent developments at length. In addition, the paper contains descriptions of:*

A two-element cable recorder code adapted to land-line transmission.

A cable printer system using a two-element code of practically the same time length as three-element recorder code.

A typical installation of Pernot superimposed cable carrier apparatus.

A brief account of the steps which have been taken to balance an inductively loaded duplex cable.

Historical Notes

PRIOR to the year 1918, transatlantic cables were worked sectionally by manual relay; that is, cablegrams were recorded and re-sent at various cable stations between New York and London, involving transcription by operators in Nova Scotia, Newfoundland, Ireland, or Cornwall, and sometimes at all four points. The year 1918 saw the first successful American attempts to repeater one long cable section into another, the result having been made possible by improvements in relays, shaping networks, and magnifiers. During the war and immediately thereafter, the combined facilities of all cable companies were not sufficient to care adequately for the traffic which was offered. Owing to the necessity of convoying cable ships, there was difficulty in having deep-sea repairs made. Sectional operation and military censorship threw a great burden of service traffic upon the cables, with the result that the congestion was sometimes so great that it could not be cleared overnight. The traffic incident to the war and later, to the negotiations for peace, overwhelmed the cable plant and served to focus attention upon the military and economic importance of adequate overseas communications.

Due largely to technical improvements in operation and an increase of cable facilities, the transatlantic cable plant is now running practically "clear" from 9 p. m., New York time, until the opening of business the following morning, and prior to 9 p. m., the load handled is about 40 per cent greater than the war time load. The developments of the last few years have therefore not only met immediate demands for cable traffic capacity but have opened opportunity for future development without additional plant cost.

An analysis of the factors which may be thought of as having given impetus to the unprecedented technical expansion of the decade just ended gives first place to the success with which automatic apparatus was adapted to landline telegraphs in the preceding decade; second, to a wide dissemination among engineers of transmission principles, epitomized in the "telegraph equation" and popularized by writers like Malcolm;[1] and third, to an economic urge produced by transoceanic radio competition with its threat to supersede cable telegraphy unless the costs of maintaining the older form of communication were substantially reduced.

To survey the accomplishments of the period under consideration in proper perspective necessitates the selection of the more important developments. In order of importance of results, these were the regenerative repeater, the inductively loaded cable, the cable printer, and a number of others given in the complete paper but not included in this abridgment.

Regenerative Repeaters

The regenerative repeater is a device for picking up the least distorted portion of successive unit signal

*General Traffic Supervisor, Western Union Telegraph Co., New York, N. Y.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930. Complete copy upon request.

1. "Theory of the Submarine Telegraph and Telephone Cable," by H. W. Malcolm, Benn Bros., London, 1917.

impulses as they arrive over a circuit, and for utilizing their respective polarities to control the formation of completely regenerated signals to be passed into another circuit The application of regenerative repeaters to cable systems is an achievement of the post-war decade.

In practise, tuning forks, vibrating in synchronism at the opposite ends of a cable section, form the basis of regenerative repeater systems. The frequency of vibration of the forks usually bears some integral ratio to the primary signaling frequency, f. (f is the frequency which is produced by an unbroken succession of unit signal impulses of opposite polarities.) Thus, a fork at Penzance, England, vibrating at frequency $5f$, may drive a multipolar synchronous motor at a constant speed such that the transmitter which is geared to the motor will send square-topped alternating current into the transatlantic section at frequency f. At Bay Roberts, Newfoundand, a fork vibrating at frequency $2f$ may be so phased with respect to the incoming signals that a contact on the tine will, in effect, be applied to the cable in the middle, or best portion, of the received unit impulses. The polarity of the incoming impulse at the instant the tine makes contact will be locked up through suitable circuits for the full duration of a unit impulse, and will determine the polarity of a "regenerated" impulse to be transmitted into the next section of line. The fork repeater[2] is the simplest of the regenerators and during the past few years has found extensive application in cable work.

All fork regenerative systems employ some method of correction of fork speed. The instant of reversal of polarity of incoming current forms a convenient datum point to which the action of the receiving fork is referred; if the phase of the receiving fork leads the incoming signal, a circuit is set up which dampens the vibration of the fork; this in turn will result in a lag of the fork behind the incoming signal, causing the setting up of a circuit which will increase speed. The fork is therefore always kept in phase, within narrow limits.

At times it is advantageous to arrange a receiving fork to drive a synchronous motor at constant frequency and to handle the received currents through brushes mounted on the motor shaft; thence through segments forming the "rings" of a distributor.[3] Such an arrangement is called a rotary regenerative repeater. The pick-up and lock-up principles do not differ radically from those employed with the fork regenerator.[2] Correction usually takes the form of a ratchet[3] or differential-gear[4] mechanism interposed in the discontinuous shaft by means of which the synchronous motor drives the brushes.

The signals which compose the letters of cable recorder code are called three-element signals because they contain impulses of positive, negative, and zero (earthed) potentials. Regenerators repeat three-element signals from cable to cable perfectly, but where landlines are involved the zero potential is not conveniently handled on account of the high level of induced currents encountered. In 1926 the Western Union first joined three-element cables to two-element landlines through a modified rotary repeater, and since then this system has afforded great flexibility in making up through cable-landline circuits. The modified rotary repeater[5] makes use of the fact that if the limiting frequency of a cable section is f, the landline to which it is connected can almost always be worked without difficulty at $2f$. Consequently the three-element signals may be converted after regeneration into two-element signals of half-unit length; the recorder "dot" becomes plus, minus; the dash becomes plus, plus; and the letter-space becomes minus, minus. The cable signal for letter "A," (dot, dash, space), regenerated from the cable at frequency f, is thus retransmitted to the landline as plus, minus, plus, plus, minus, minus, at frequency $2f$. This signal can be repeatered through any standard landline repeater. At the terminal the signal is "unscrambled" by means of a fork running at frequency $4f$ and suitable relay circuits, and is read by the operator as ordinary three-element cable recorder code.

The regenerator has had several marked effects upon the fortunes of all the cable companies. First, it has resulted in labor savings at repeater stations of the order of 70 per cent of the total staff in attendance. Second, it has met the challenge of the transoceanic radio for "direct" connections. New York is now electrically connected by the cables of various companies with London, Liverpool, Irish Free State, Emden, Berlin, Havre, Paris, the Azores, Havana, Mexico City, Barbados, Pernambuco, Rio de Janeiro, Valparaiso, and Buenos Aires, and several intermediate points. A third effect of the regenerator has been to improve the speed of service on the bulk of traffic, as compared with the purely specialized handling of important files that was common in days of manual relay. Fourth, the accuracy of the service has been improved, both by reduction of the hazard incident to the handling of messages by many operators, and by the substitution of a bold, easily read signal for the old-time distorted characters.

Inductively Loaded Cables

The principles involved in the improvement of transmission of cable signals by inductive loading have been understood for many years, but their application has been the work of the past decade.

Inductive loading may be lumped, continuous, or tapered. The latter two methods have proved to be

2. *Printing Telegraphs on Non-Loaded Ocean Cables*, by Herbert Angel, A. I. E. E., Trans., Vol. XLVI, 1927, p. 884.

3. *Printing Telegraph Systems*, by J. H. Bell, A. I. E. E. Trans., Vol. 39, Part 1, 1920.

4. "Automatic Printing Equipment for Long Loaded Submarine Telegraph Cables," by A. A. Clokey, *Bell System Tech. Jl.*, Vol. VI, July 1927, p. 402.

5. C. F. Nelson, U. S. Patent, 1927.

practical on long cables, continuous loading being optimum for one-way operation and tapered loading for duplex operation. Both methods employ permalloy,[6] an American-made alloy, or mu-metal, a similar foreign product, applied in the form of a continuous helix of tape or wire wound around the cable conductor as an axis, and contiguous to it.

There are now four continuously loaded cable sections and one taper-loaded cable in operation in the Atlantic. Two of the four continuously loaded sections are repeatered to form one four-channel unidirectional cable between New York and London, operated by the Western Union; and the other two sections are repeatered to form one five-channel unidirectional cable between New York and Emden, Germany, with one channel dropped at Horta and operated jointly by Western Union, Commercial Cable Company, and German Atlantic Telegraph Company. The present unidirectional printer operating speeds of these cables are 67.5 and 65.0 cycles per sec., respectively, (two-element signals).

The Bay Roberts-Horta cable laid in 1928 is taper-loaded, the end sections being unloaded. It has a nominal one-way speed of 77.6 cycles per sec., (2500 letters per minute, three-element). Western Union engineers have successfully balanced this cable at one end, at 43.4 cycles per sec., (1400 letters per minute, three-element); equipment is now being manufactured for the other end.

In this case, the balance was obtained by the method of wave reflections from points on cable and artificial line where impedances abruptly change, using the oscillograph[7] as a tool. A single impulse traveling simultaneously along cable and artificial line is reflected at each point where the surge impedance changes. If there is a lack of correspondence between main and artificial lines at a point reached by the wave at time t after the wave starts, a momentary difference of potential across the cable bridge will due to reflection, exist at time $2\,t$. The artificial line is then adjusted until at time $2\,t$ no difference of potential exists. Attention may then be given to conditions at time $2\,(t + d\,t)$, etc., until a straight line is obtained on the oscillograph, denoting "perfect" balance. Many practical difficulties, due to double reflections, effect of sea-earth, etc., had to be overcome in practise to secure a balance.

The artificial line network used on this cable may be described as a succession of inductance units jointed in series, paralleled by a succession of resistance units joined in series, and the two series cross-connected at their respective joints by condenser units. The values are so chosen that the cable, as nearly as possible, is matched in impedance throughout its length, due regard being given to the relative importance of the portion of line nearest the terminal.

The considerations which result in the decision to lay a duplex loaded cable instead of a unidirectional cable are complicated. Each time the question comes up, the situation must be investigated from many angles, of which the rate of flow of traffic in each direction during different hours of the day is one of the most important, as is also the allocation of paralleling facilities to various uses. Since it is possible to secure from the duplexed cable referred to above an output of 2800 letters per min. as compared with a net unidirectional speed of 2380 letters per min. (deducting 5 per cent lost time for automatic turn-around), the duplex operation of a taper loaded cable would appear to be optimum. A continuously loaded cable having the same unidirectional speed would require less copper but more miles of loading; the element of cost, therefore, has to be considered in determining whether to lay a duplexed or unidirectional cable.

At the present state of the art, unidirectional loaded cables are being utilized for handling "bulk" traffic of ordinary and deferred classes, while the old type cables are being deployed for the fast specialized services.

Printers

Printing telegraphs have been well established in landline practise for many years; their application to loaded and non-loaded cables is the product of the post-war decade.

Adaptation of printers to high-speed unidirectional cables has been made practicable by[4] (a) utilization of vibrating circuits for fill-in purposes, (b) brush-driven vibrating circuits, (c) automatic turn-around, with provision made for stopping and starting transmitters and printers, and short-circuiting amplifiers, stage by stage, (d) improvement in relays, in distributor prime-movers, and in means for controlling phase relationships of sending and receiving brushes, (e) provision for sending Morse at low frequencies over the cable without paralyzing the amplifiers.

The application of printing systems to old type duplex cables[2] has been complicated by balance troubles. While the system of attenuation of single impulses can be carried on successfully at the receiving end of the cable, the application of double frequency at the sending end puts a burden on the balance too great to be taken care of at present. The high speeds handled also introduce problems of variable lag,[2] all of which have not as yet been solved. Up to the present time, the use of printers on old type cables, in so far as they have duplicated the performance of recorders, has been successful, but for purely traffic reasons their installation in combination with recorder circuits in the same offices has not produced notable gains in operating economy.

A new type of printer system[8] is now being tried out

6. *The Loaded Submarine Telegraph Cable*, by Oliver E. Buckley, A. I. E. E. Trans., Vol. XLIV, 1925, p. 882.

7. Described by J. J. Gilbert, in an article: "Determination of Electrical Characteristics of Loaded Telegraph Cables," *Bell System Tech. Jl.*, Vol. VI, July, 1927.

8. H. Angel and J. W. Robinson, patent applied for.

to avoid some of the troubles previously encountered. It makes use of Murray-Baudot five-unit two-element uniform code, reconstructed into a non-uniform two-element code, wherein the letters are from 6 to 9 half-units in length, the average number of full-length impulses per letter being 3.50, comparing with 3.71 for cable recorder code. Marking impulses of Baudot are transmitted full length, there being arbitrary reversal of polarity between each two successive marking impulses; spacing impulses are transmitted at half-length, the polarity of any number of them in succession from one up, being the same as the marking impulse which preceded them. Thus the letter *W*, which in Baudot is *M, M, S, S, M*,[9] in the Angel modification becomes + +, − −, −, −, + +, each of the units being half the length of those in Baudot. The letter *F* in Baudot is *M, S, M, M, S*; in Angel code it is + +, +, − −, + +, +. The perforator, transmitter, and printer are the same as used in Baudot operation. The printer has the interesting and valuable feature of "going into pi" whenever a line hit or repeater fault occurs; this is caused by the non-uniform code, which results in the printer's going out of step when one letter is mutilated; but the receiving operator can restore synchronism with a push-button and get a correction by *R Q* and *B Q*.[10] It will be noted that the code is so constituted that the half-units never occur singly, hence the code is handled at the same line frequency as Baudot and no undue demands are made of artificial line balances. It is to be observed also that while the double impulses are of length *L*, the same as single impulses in Baudot, the receiving margin must be such that signals of length 1.5 *L* can be distinguished from those of length *L*.

Superimposed Circuits

One development that has created interest among cable men is the Pernot system of superimposed a-c. signals, which has been applied to short sections of cable by several different companies. A short description of some of the constants of the Western Union's North Sydney, N. S.-Hearts Content, Nfld., installation follows.

The cable itself runs from Canso, N. S., to Hearts Content, being looped into North Sydney. On the d-c. side, it is balanced for duplex working at Canso and Hearts Content, being operated at 8.0 cycles per sec., (260 letters per minute, three-element recorder), and jointed through rotary regenerative repeaters at Canso with a cable going to New York, and at Hearts Content with a transatlantic section. The operation of this circuit has not been disturbed by the Pernot application.

The a-c. side is operated duplex on the North Sydney-Hearts Content section at a speed of 5.0 cycles per sec. to 7.5 cycles per sec., (160 letters per min. to 240 letters per min., three-element recorder), and joined through a fork repeater at North Sydney with a New York landline, and through a three-element repeater at Hearts Content with a landline going to Bay Roberts, Nfld., rotary repeater, a few miles distant.

The a-c. side has a 50-cycles-per-sec. carrier for eastward transmission and an 80-cycles-per-sec. carrier for westward transmission. Since the primary signaling frequency *f* of the alternating current may be 5.0 cycles per sec. to 7.5 cycles per sec., the unit signal impulse modulates from 5 to 8 cycles of the carrier.

The required three values of current for three-element operation are provided by exciting the field of the alternator to zero, half, and full value, these values being controlled by the usual cable sending-on relays. At the receiving end, the received high-frequency signals are amplified and rectified and the envelopes of signals are caused to upset an impedance bridge. Currents of zero, half, and full magnitude are thus sent through the mechanically biased coil of a drum relay, the contact of which is adjusted to rest on "No Man's Land" when the modulating current is at half value. Full current modulation gives a "dot" contact and zero modulation a "dash" contact.

Conclusion

Enough has been presented[11] in the foregoing outline of the accomplishments of the post-war decade to indicate that at its close we are dealing with cable transmitting speeds of a different order of magnitude from those characteristic of its beginning. There has been a corresponding satisfactory increase in patronage and consequent prosperity for the cable companies, which may be considered in the light of a guaranty of further technical developments in years to come. It is fairly safe to predict that there will be increasing utilization of electrically repeatered landline feeders to high-speed ocean cable sections affording a large number of direct connections between the important cabling cities of the American and European continents. There have been recent announcements by the Bell System to the effect that we may expect further increases of cable speed through improvement of cable dielectric and armoring, making it possible to handle voice frequencies as well as those used for telegraphic signaling. The future, therefore, promises much of interest to engineers connected with one of the oldest and now one of the liveliest of the electrical arts.

9. *M* stands for *marking*, *S* for *spacing*. The commas have no significance except to clarify the conversion.

10. *R Q s* and *B Q s* constitute "service" requests for information and replies thereto.

11. The following references may be consulted for further information:

Submarine Cable Telegraphy, by J. Willard Milnor, A. I. E. E. Trans., Vol. XLI, 1922, p. 20.

Certain Factors Affecting Telegraph Speed, by H. Nyquist, A. I. E. E. Trans., Vol. XLIII, Feb. 1924.

"High-Speed Ocean Cable Telegraphy," by O. E. Buckley, *Bell System Tech. Jl.*, April, 1928.

A Non-Rotary Regenerative Telegraph Repeater, by A. F. Connery, A. I. E. E. Trans., Vol. XLVI, 1927, p. 897.

"The Application of Vacuum Tube Amplifiers to Submarine Telegraph Cables," by Austin M. Curtis, *Bell System Tech. Jl.*, Vol. VI, July, 1927.

"Recent Developments in Submarine Cable Design," by R. L. Hughes, *I. E. E. Jl.*, (London), Vol. 66, 1927, p. 140.

Abridgment of

Behavior of Dielectrics

A Study of the Anomalous Charging Current and the Variation of Dielectric Energy Loss and Capacitance with Frequency in Solid Dielectrics

BY R. R. BENEDICT*

Associate, A. I. E. E.

***Synopsis.**—The paper describes a research undertaken with the object of throwing light on the relations between the electrical properties of dielectrics or insulating materials, especially on the relation between the "anomalous charging current" under a direct voltage test and the dielectric energy loss for an impressed alternating voltage.*

After a review of the theory of this relationahip, the methods developed in this study for observing the anomalous charging current in condensers in the time range from 0.0007 to 0.100 sec. after impressing a steady potential are described. The methods used in observing the "normal leakage current" and the alternating energy loss and capacitance in the frequency range from 200 to 4000 cycles per sec. are also described.

The results of measurements by these methods on mica, glass, treated cloth, and paraffin paper condensers are given. These measurements include a series giving the effect of varying temperature on the properties of the glass and treated cloth condensers.

Finally, the comparisons between the dielectric energy loss and capacitance variation with frequency predicted on the basis of the d-c. anomalous charging current tests and the variations which were actually observed are given. These comparisons show that a fair agreement exists between the predicted and observed curves.

I. Introduction

IT has been known for some time that an intimate relation exists between the anomalous effects in dielectrics observed with a direct voltage applied and the phenomena of alternating dielectric energy loss and the variation of capacitance with frequency. The theoretical work of von Schweidler[1] gave a quantitative basis for the correlation of the d-c. and the a-c. phenomena. F. Tank, from his measurements of the anomalous charging current of the condensers with direct voltage applied, was able to predict the alternating loss in several condensers at a frequency of 50 cycles per sec. It was the object of the present study to measure the anomalous charging current curves for a series of condensers with direct voltage applied and then to compare the predicted frequency variations of loss and capacitance of the same condensers with the variations which were experimentally determined.

II. Theoretical Discussion

The Anomalous Charging Current of a Condenser. Suppose a condenser (having a solid dielectric such as glass, paraffin, or rubber) is connected by a circuit of low resistance and inductance to a source of constant voltage E: A "normal charge" will then flow into the condenser, giving rise to the transient *normal charging current* which rapidly approaches zero. If the condenser has a solid dielectric, an additional current is superimposed on the normal charging current. This additional current is considered to have two components, the *normal conduction current* and the *anomalous charging current.* The final leakage current after a sufficient time has elapsed so that this current has reached a steady value has been called the *normal conduction current.* The difference obtained by subtracting the sum of the normal conduction current and the normal charging current from the total observed current gives a component of current in the circuit which may be called the *anomalous charging current.* The anomalous charging current is closely associated with the anomalous effects observed in solid dielectrics, such as the residual voltage of condensers, the losses in alternating fields, and the variation of capacitance of a condenser with varying frequency of the alternating field. This anomalous charging current has received a great amount of study and in general it has been found to be governed by two laws. One of these laws, which gives the relation between the ordinates of the anomalous charging current curve and the steady voltage and the capacitance of the condenser, may be represented by Equation (**1**):

$$i_a = E\, C_0\, \Phi\,(t) \qquad (1)$$

Here C_0 is the geometric capacitance of the condenser, and $\Phi\,(t)$ gives the time variation of the anomalous charging current.

The second law governing the anomalous charging current curves is the *principle of superposition,* which may be stated as follows: the anomalous charging current term associated with a given increment in the impressed voltage is independent of the preceding

*Instructor in Electrical Engineering, University of Wisconsin, Madison, Wis.

1. For references see the complete paper.

†See extended bibliographies of E. von Schweidler,[4] E. H. Raynor,[5] D. M. Simons,[6] J. B. Whitehead.[7]

‡See the thorough discussion of these theories by J. B. Whitehead.[7]

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 27-31, 1930. Complete copy upon request.

values of the impressed voltage. This principle has been generalized to give an expression which makes possible the calculation of the anomalous charging current at any time t after the application of a voltage which is an arbitrary function of the time $E(\tau)$. This is

$$i_a = C_0 \int_{-\infty}^{t} \frac{d\,E(\tau)}{d\,\tau}\,\Phi(t-\tau)\,d\,\tau, \qquad (2)$$

where the Φ function is the same as in Eq. (1). This formula makes possible the calculation of the dielectric loss accompanying an impressed alternating voltage.

If we put in a sinusoidal voltage for the function $E(\tau)$ in Eq. (2), then the solution of the integral will show that the alternating anomalous charging current has two components. One of these components of current has the same effect as increasing the capacitance of the condenser, and the other has the effect of giving rise to a loss of energy in the condenser. Many experimenters have found that the function $\Phi(t)$ in Eq. (1) may be represented by the empirical relation

$$\Phi(t) = \beta\,t^{-n} \qquad (3)$$

When this is true, the effect of the alternating anomalous charging current on the capacitance and the tangent of the phase difference angle ϕ as computed by Eq. (2) may be given by Eq. (4) and (5):

$$C = C_0\left[1 + \frac{\beta\,\Gamma(1-n)\cos(1-n)\,\pi/2}{\omega^{(1-n)}}\right] \qquad (4)$$

$$\tan\phi = \frac{\beta\,\pi}{[\,\omega^{(1-n)}\,2\,\Gamma(n)\,\cos(1-n)\,\pi/2]\,C/C_0}. \qquad (5)$$

Here Γ is the "gamma" function. Equations (4) and (5) show that for the values of n between zero and one for which this solution holds, the apparent capacitance and the phase difference should decrease as the frequency increases.

If the function $\Phi(t)$ as given in Eq. (3) is put in Eq. (1), we obtain the following expression for the anomalous charging current with a steady impressed voltage:

$$i_a = E\,C_0\,\phi\,t^{-n} \qquad (6)$$

The constants β and n may be looked on as constants of the material of the condenser at the given temperature. These constants were determined by the tests with a steady voltage impressed on the condenser, and after these constants had been determined, the capacitance and phase difference were calculated by Eqs. (4) and (5). The results of these calculations were compared with the observed variations of capacitance and frequency.

III. Experimental Methods

The determination of the anomalous charging current curves for short time intervals after the application of a steady potential requires the measurement of rapidly varying currents of small magnitude. By means of the circuit and switching arrangement shown in Fig. 1, the trace of the anomalous charging current of condenser C, upon connecting it to the battery E, is photographically recorded by the oscillograph vibrator V. In this circuit, the two switches S_2 and S_3 are opened by a bullet fired from the gun M. The switches S_2 and S_3 are small phosphor-bronze strips which are destroyed by the bullet. Initially the switch S_1 is open and the switches S_2 and S_3 are closed. The first operation in obtaining a test of the anomalous charging current is the closing of switch S_1. At the same time the string attached to the switch S_1 pulls the trigger on the oscillograph. Upon closing switch S_1, current builds up in the circuit $A\,S_1\,B\,D\,L\,F\,G\,H\,A$. The battery voltage is, say, 100 volts; and the resistance R_1 is 2000 ohms. The current in the circuit has become practically steady after one microsecond.

The opening of the shutter on the oscillograph causes the relay which triggers the gun to be energized. This relay is so adjusted that the bullet does not open switch S_2 until the zero lines have been traced for some distance on the film. When the bullet opens switch S_2

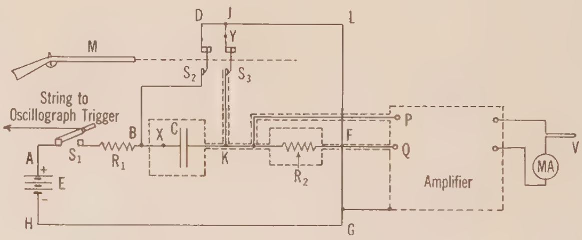

Fig. 1—Circuit for Measuring Anomalous Charging Current of Condensers

the shunt $B\,D\,J\,K$ is removed from the condenser C which is under test. The condenser C of, say, 2×10^{-9} farads capacitance then begins to charge; and after 0.08 mil-sec., the voltage of the condenser is within 2×10^{-7} volts of the battery voltage and the normal charging current will be less than 10^{-10} amperes.

The bullet from the 0.22 caliber gun opens the switch S_3 at a time 0.08 mil-sec. after opening the switch S_2. When the switch S_3 is opened, it removes the shunt $K\,J\,L\,F$ from the resistance R_2 and the anomalous charging current and leakage current of the condenser must flow through this resistance R_2, thereby setting up a difference of potential between the terminals K and F of the resistance. This difference of potential is proportional to the instantaneous value of the current, and it is impressed on the amplifier terminals P, Q. The output current of the amplifier is recorded by the oscillograph vibrator V, thus giving a record of the anomalous charging current plus the leakage current of the condenser.

The amplifier was a three-stage so-called d-c. amplifier. The values of the anomalous charging currents were derived from the deflections on the films by the aid of the calibration of the oscillograph vibrator and the

d-c. calibration of the amplifier. The reliability of this method was tested by introducing a current of calculable time variation in the test circuit and comparing the calculated current with that derived from the oscillograms.

A sample record showing two tests of the anomalous charging current of a condenser is shown in Fig. 5. From this it may be seen that the anomalous charging current drops very rapidly with time. A modification of the method described above was developed in order to obtain larger deflections after a time of about 8 mil-sec.

In addition to the measurements of the anomalous charging current, tests were made of the final leakage current and of the variation of alternating power loss and capacitance with frequency. The leakage currents were measured by the simple galvanometer method. A bridge method was used for the measurement of the alternating power loss and capacitance of the condensers. Measurements were taken in the frequency range from 200 to 4000 cycles per second.

The four condensers that were tested had dielectrics of mica, treated cloth, paraffin paper, and glass. The mica condenser was a commercial condenser, while the others were made in the laboratory. The condensers were mounted in a heating box which was fitted with automatic temperature-controlling apparatus.

IV. Results of Tests

The anomalous charging current curves were obtained by subtracting the final leakage current from the currents derived from the oscillograph records. The resulting curves were plotted to double logarithmic

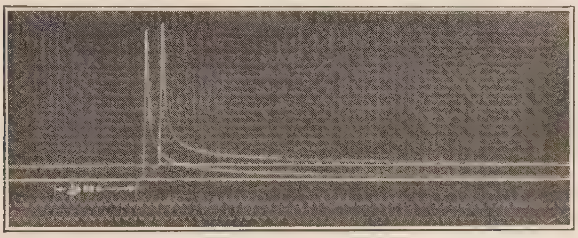

Fig. 5—Tests of Condenser 36 (Treated Cloth)

Film 302 E = 97.0 volts R_2 = 6000 ohms
Condenser temperature = 60.0 deg. cent.
Damping fluid temperature = 42 deg. cent.
Frequency of timing wave = 1000 cycles per second

scales as shown in Fig. 11.* In this figure, the points obtained from the short-time method of test have been indicated by circles or open figures, and the results of the modified method of test by dots or closed figures. From two to five records were taken for each condenser at each temperature by both methods of test. The straight lines which are drawn in the graph are represented by the formula $i_a = k\,t^{-n}$. In nearly all cases the observations fall along these straight lines, and, therefore the anomalous charging current may be represented by Eq. (6):

$$i_a = E\,C_0\,\beta\,t^{-n} \qquad (6)$$

The constants β and n were determined from the straight lines in Fig. 11. The values of C_0 needed in order to determine these constants were obtained by a method of successive approximations from the measured capacitance at 4000 cycles per second. The values of the

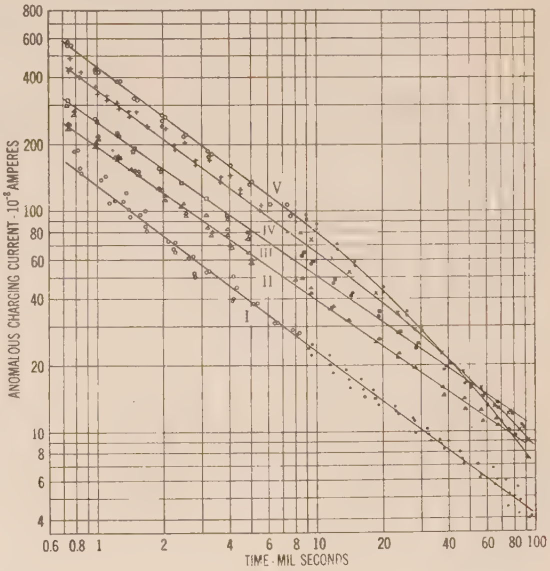

Fig. 11—Tests of Condenser 36 (Treated Cloth) E = 99 Volts

Curve I condenser temperature = 30 deg. cent.
Curve II condenser temperature = 40 deg. cent.
Curve III condenser temperature = 50 deg. cent.
Curve IV condenser temperature = 60 deg. cent.
Curve V condenser temperature = 70 deg. cent.

constants β and n, together with the values of C_0 and the relative permittivities or dielectric constants, are given in Table II.

TABLE II
RESULTS FOR CONSTANTS IN THE ANOMALOUS CHARGING CURRENT FORMULA, EQUATION (6)

Condenser	Temp. deg. cent.	Constants in the anomalous charging current formula, Equation (6)			Relative permittivity p_r
		β	n	$C_0 - 10^{-9}$ farads	
35-(Soda-lime glass)	30	0.113	0.75	0.789	7.15
	40	0.211	0.70	0.800	7.25
	50	0.317	0.67	0.810	7.35
	60	0.396	0.69	0.804	7.29
	70	0.531	0.69	0.806	7.31
35 (Varnished cloth)	30	0.165	0.75	0.448	3.82
	40	0.367	0.69	0.464	3.96
	50	0.456	0.69	0.475	4.05
	60	0.486	0.73	0.471	4.02
	70	0.588	0.74	0.471	4.02
37 (Paraffin paper)	30	0.00765	0.92	1.510	3.6
39 (Mica)	30	0.0255	0.63	0.945	6.3

*For the curves for glass, mica, and paraffin paper see complete paper.

The results of the measurements of power factor and capacitance of the treated cloth test condenser are given in Figs. 14 and 17. The curves between the tangent of the phase difference angle (or approximately the power factor) and the frequency are approximately straight lines for treated cloth condenser 36 at the low temperatures. This shows that the relation between $\tan \phi$ and the frequency may be represented by an equation of the form of Eq. (**5**) if the normal conduction loss is small. The proportion of the normal conduction loss based on the ultimate leakage current measure-

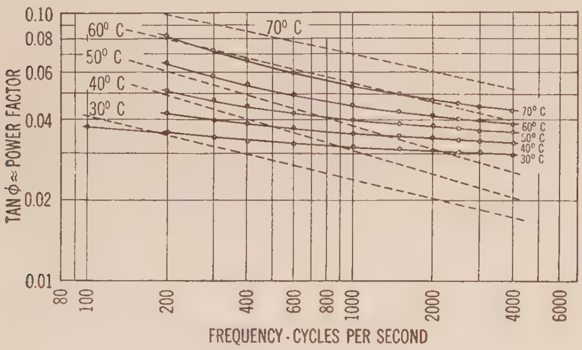

Fig. 14—Comparison of Measured and Calculated Power Factor Variation with Frequency for Condenser 36 (Treated Cloth)

———o— Measured
– – – – – Calculated on the basis of the measured anomalous charging current

ments to the total measured loss was computed for a frequency of 200 cycles per sec. The percentage conduction loss varied from 0.1 per cent at 30 deg. cent. to about 7 per cent at 70 deg. cent., and therefore this loss was small compared to the total loss.

The determination of the anomalous charging current curves for the condensers makes possible the calculation of the behavior of the condenser under alternating electromotive force. The results for the constants β and n were used in Eqs. (**4**) and (**5**) to calculate the power factor and capacitance of the condensers at different frequencies The calculated curves are represented by the dash lines in Figs. 14 and 17. In these figures, the measured values are spotted and represented by the full curves.

The calculated curves, in general, are in fair agreement with the observed curves. The power-factor curves are in better agreement at the low-frequency end of the range. This may be said to be the result of the time range over which the anomalous charging current measurements were made. If the anomalous charging currents had been measured for shorter time intervals after impressing the voltage, the agreement between calculated and observed power factor might be expected to be better at the higher frequencies. The measured value of the capacitance at 4000 cycles per sec. was used as a basis for computing the geometric capacitance C_0, and therefore was also the basis for the predicted curves in Fig. 17.

V. Conclusions

These experiments show that for the dielectrics studied the empirical equation

$$i_a = E\, C_0\, \beta\, t^{-n} \tag{6}$$

is a good approximation for the anomalous charging current in the time range studied; namely, for the interval from 0.7 to 100 mil-sec. after impressing the charging electromotive force. In this formula the constants β and n are constants of the dielectric which depend, however, on its temperature, moisture content, impurities, previous preparation, etc.

The tests at elevated temperatures on the glass and treated cloth condensers showed that the value of n remains nearly constant as the temperature is increased, while the value of β increases rapidly.

The alternating anomalous charging current as computed from the $\beta\, t^{-n}$ function derived from the d-c. measurements is sufficient to account for the major portion of the losses at low frequency in the solid dielectrics studied. For these dielectrics, the computed loss based on the normal leakage current varied from less than one-half of one per cent of the total measured loss at a temperature of 30 deg. cent. to a maximum of about 7 per cent at 70 deg. cent. These values were computed at a frequency of 200 cycles per second.

The capacitance variation with frequency as com-

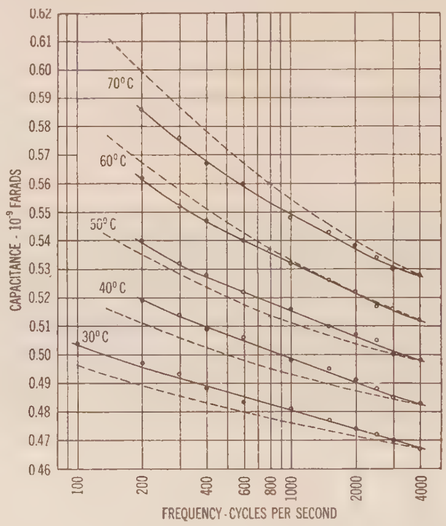

Fig. 17—Comparison of Measured and Calculated Capacitance Variation with Frequency for Condenser 36 (Treated Cloth)

———o— Measured
– – – – – Calculated on the basis of the measured anomalous charging current

puted on the basis of the measured anomalous charging current is in fair agreement with the measured variation in the frequency range studied.

Acknowledgment

I wish to acknowledge my indebtedness to Professor Edward Bennett for valuable suggestions and counsel, and to the Wisconsin Utilities Association and the Regents of the University of Wisconsin for financial aid for this work.

Abridgment of

Double Windings for Turbine Alternators

BY PHILIP L. ALGER,* E. H. FREIBURGHOUSE,* and D. D. CHASE*

Member, A. I. E. E. Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—Large turbine alternators with two similar independent armature windings to permit the electrical segregation of bus sections in large stations without loss of synchronizing power have recently been proposed. Several such generators have been installed or are under construction, and it now seems that they will become of paramount importance in very large future stations. This paper explains the theory and design limitations of these double-winding generators, and describes their application in systems having different types of bus connections.

* * * * *

I. Introduction

A VERY recent development in the design of large steam turbine-driven alternators is the use of two electrically independent similar armature windings. By loading the windings independently, the advantages of a higher generator reactance, and hence, lower fault currents, are obtained, while yet retaining adequate synchronizing power. Also, by connecting the windings to adjacent sections of a sectionalized ring bus, the sections will be effectively separated by a high "through" reactance, thus limiting the current flow on faults while still permitting, by virtue of the transformer action between the two windings, power flow between sections.

These characteristics mean the elimination of bus reactors and a reduction in the required circuit breaker capacity, so that the double-winding generator is likely to be extensively utilized in large stations of the future.

The first unit of this type to be installed is the 60-cycle, 83,333-kv-a., 13,800-volt generator, which, since the latter part of September 1929, has been in operation in the Cahokia Station of the Union Electric Light and Power Company at St. Louis. The second is the 25-cycle 160,000-kv-a. unity-power-factor 11,400-volt generator of the New York Edison Company, which was placed in service early in October. Several others are now under construction.

Multiple circuit armatures have been commonly used for many years to reduce the currents individual conductors are required to carry, but since any inequality of circuit currents normally gives rise to an irregular flux distribution, causing extra power losses and abnormal mechanical stresses their circuits were not suitable for independent loading. Only two types of winding are considered suitable for the purposes mentioned above; the alternate slot type, (shown in Fig. 2), and the split belt type (Fig. 3). In the former, the two independently loaded circuits lie in alternate slots with no two coil sides of different circuits lying in the same slot. In the latter, each phase belt of a single-winding machine is divided into two approximately equal portions, of which one is assigned to each circuit; and the sequence of half belts in each circuit is so selected as to give perfect circuit and phase balance while minimizing the number of slots carrying coil sides of different circuits. Either type of winding can be loaded unequally up to the limit allowed by armature heating without important disturbance of the symmetry of the magnetic fields and without introducing unusual stray losses or mechanical forces.

The alternate slot type gives perfect magnetic symmetry with unequal loading but has its transfer reactance considerably reduced by saturation under excessive fault currents. The reactance of the split belt type is less affected by saturation but this winding

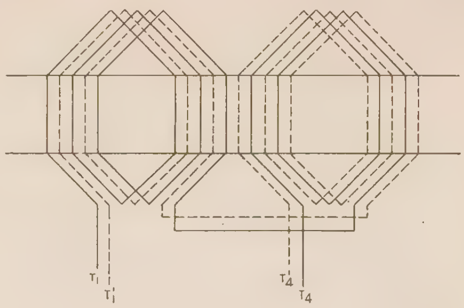

Fig. 2—Schematic Diagram of Alternate Slot Double-Winding Generator

Fractional pitch, one-phase per pole indicated for each winding

gives an appreciable dissymmetry of the magnetic field and slight extra losses with unequal loading. The latter type is recommended for general use as it enables the minimum of reactor capacity to be used with no real sacrifice in performance. The two machines mentioned above, however, have alternate slot windings.

The alternate pole type of winding is distinctly desirable, as it gives low "through" slot reactance, unless approximately two thirds pitch is used and it gives large stray losses with unequal loading. Also, the magnetic forces on the end windings during a short circuit are much greater than with the two types of winding.

Tests on an alternate slot-wound 350-hp. synchronous motor showed no appreciably greater loss with one

---

*All of the Engineering Department, General Electric Company, Schenectady, New York.

Presented at the Great Lakes District Meeting of the A. I. E. E., Chicago, Ill., Dec. 2-4, 1929. Complete copy upon request.

than with both windings for the same total current, though curve a of Fig. 13 shows an appreciable increase for the similarly wound model generator. This indication that the same type of dissymmetry causes greater losses with the solid steel rotor construction than with the laminated pole and copper squirrel-cage construction is confirmed by comparing curves d and c for alternate-pole wound machines of these types.

In the alternate-pole winding, when one winding

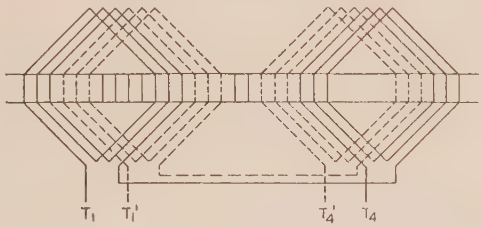

Fig. 3—Schematic Diagram of Split Phase Belt Double-Winding Generator

Fractional pitch, one-phase per pole indicated for each winding

alone carries current, the end leakage flux is bunched in alternate-pole pitches, creating not only local concentration of flux in the armature shields and flanges, but also eddy currents in the rotor retaining rings. This is the principal reason for the high losses shown by curve d.

Since these are both attracted by the remainder of

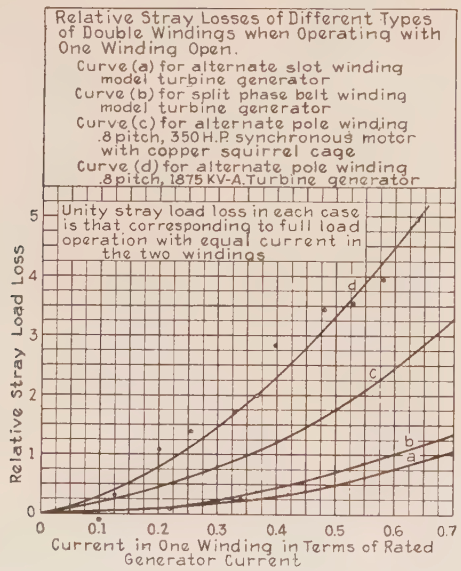

Fig. 13

the phase belt and repelled by the out-of-phase current in the adjacent phase belt the magnetic forces on the end windings are greatest on the end conductors of phase belts. In practise, it may be expected that any double-winding machine with a fault on one winding only will deliver about 0.7 as much instantaneous current as the corresponding single winding machine, so the proper comparison of maximum forces is made by taking the current in the double winding machine as 0.7 that in the single winding machine. On this basis, the relative forces to which the end windings are subjected in practise for the single-circuit alternate-pole alternate-slot, and split-belt windings are about in the ratios of 1 to 1.9 to 0.8 to 1.2, respectively. The split-belt winding is satisfactory from this point of view, while

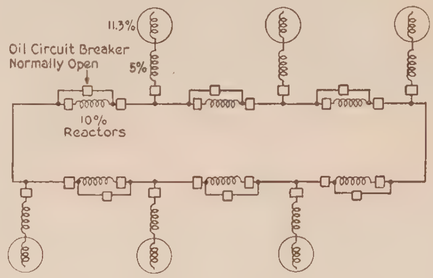

Fig. 14—Standard Ring Bus System. Case I

the alternate-pole winding is definitely inferior to the other types.

II. Applications of Double Winding Generators

The advantages resulting from the use of double-winding generators in large stations may best be shown by comparing the fault currents and the amount of

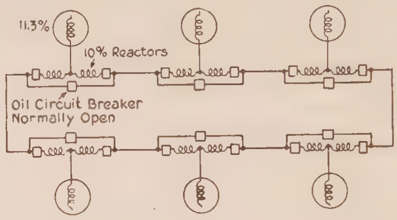

Fig. 15—Modified Ring Bus System with Standard Generators. Case II

protective equipment required with the usual systems of bus connections, using single and double winding generators. Five arrangements will be considered:

1. The standard ring bus with bus reactors (Fig. 14).
2. A ring bus with generator reactors, utilized also as bus reactors, with single winding generators (Fig. 15).

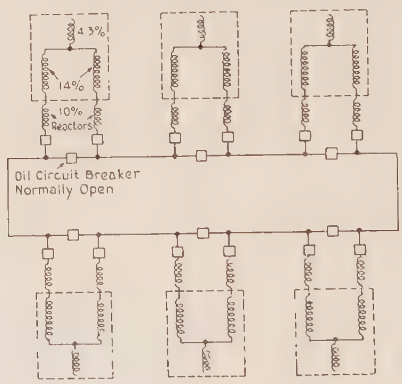

Fig. 16—New Ring Bus System with Double-Winding Generators. Case III

3. A ring bus with double-winding generators, using alternate-slot arrangement of windings (Fig. 16).

3a. A ring bus with double-winding generators, using split-belt arrangement of windings (Fig. 16).

TABULATION FOR A THREE-PHASE FAULT ON THE BUS IN TYPES OF STATIONS AS SHOWN IN CASES I TO V, FIGS. 14 TO 18 OF THE COMPLETE PAPER

All Breakers and Reactors as Listed per Generator are for Double Bus Generators Rated ATB-4-150,000 Kv-a.-1800-13,800-Volts 0.85 Power Factor-6280 Amperes

	Case I Fig. 14	Case II Fig. 15	Case III Fig. 16	Case IIIA Fig. 16	Case IV Fig. 17	Case V Fig. 18
Limit of kv-a. transfer along bus	150,000	75,000	15,000	15,000	150,000	75,000
No. of breakers per generator	8	6	6	6	6	10
Ampere rating of oil circuit breakers	6,300	6,300	4,000	4,000	6,300	4,000
No. of reactors required	3	2	2	2	2	4
Rating of reactors	6,300	6,300	4,000	4,000	6,300	4,000
Preferred arrangement, limiting all breakers and reactors to 4000-ampere rating						
No. of breakers required	16	12	6	6	12	10
No. of reactors required	6	4	2	2	4	4
Limit of kv-a. transfer along bus	95,000	20,000	15,000	15,000		
No. of breakers per generator	10	6	6	6		
Ampere rating of breakers	4,000	4,000	4,000	4,000		
No. of reactors required	4	2	2	2		
Ampere rating of reactors	4,000	4,000	4,000	4,000		
Instantaneous symmetrical kv-a. to fault	2,470,000	1,660,000	1,370,000	1,216,000	1,900,000	1,200,000
Sustained kv-a. to fault	985,000	780,000	580,000	560,000	830,000	660,000
Instantaneous r. m. s. symmetrical amperes	103,000	69,500	57,000	51,000	79,500	50,000
Sustained fault amperes	41,200	32,600	24,300	23,500	34,800	37,700
Percentage instantaneous voltage on faulted bus	0	0	0	0	0	0
Percentage instantaneous voltage on bus next to fault	51	71	89	92	78	88
Percentage instantaneous voltage on 2nd bus from fault	74	91	99	99		
Percentage instantaneous voltage on 3rd bus from fault	80	96	99	99		
Percentage instantaneous voltage on synchronizing bus					65	80
Percentage sustained voltage on faulted bus	0	0	0	0	0	0
Percentage sustained voltage on bus next to fault	25	40	54	58	48	60
Percentage sustained voltage on 2nd bus from fault	39	59	79	81		
Percentage sustained voltage on 3rd bus from fault	43	65	86	87		
Percentage sustained voltage on synchronizing bus					40	54
Instantaneous sym. kv-a. to synchronizing bus fault					3,420,000	3,420,000
Sustained kv-a. to synchronizing bus fault					1,200,000	1,200,000
Instantaneous r. m. s. sym. amps. to synchronizing bus fault					143,000	143,000
Sustained r. m. s. sym. amps. to synchronizing bus fault					50,000	50,000

4. A star bus with single-winding generators.
5. A star bus with double-winding generators using split-belt arrangement of windings.

All the system diagrams shown are simplified by showing only a single bus, although a double bus arrangement is standard in the United States. The characteristics of the five systems using 150,000-kv-a. 13,800-volt generators are compared in the accompanying tabulation, the per unit subtransient reactance of the two windings in parallel being taken as 0.113, of which 0.043 is mutual for the alternate-slot case. In making the calculations for this comparison, the double bus was used throughout, and it was assumed in all cases that there were no external power ties to the system, although it is usual for several stations to be interconnected. This assumption makes the advantages shown for the double-winding generator appear less than they really are, as any additional current supplied to a fault by the connected stations increases the importance of any means of limiting the current supplied by the station itself. Generator reactors, or their equivalent, have been used in all cases, in order to secure the advantages of a higher bus voltage and lower fault currents during faults in the generators themselves, or their connecting cables, and to reduce the currents supplied by the generators to external faults.

The important characteristics which affect the choice of generator and bus connections are the magnitudes of the fault currents, and the numbers and sizes of circuit breakers and reactors required to permit flexible operation and give adequate protection. Accordingly, these quantities have been calculated for each of the five systems, and are shown in the table. The first five lines of the table were compiled on the basis of unlimited ampere capacity of the circuit breakers. The 6300-ampere breakers required in three of the systems are larger than desirable, however, as most operating companies prefer to use 4000-ampere breakers, or smaller if possible, and as the manufacturers prefer to limit the sizes to their present developed lines. The largest breakers so far built by the General Electric Company are for the double tank per phase type, 6000 amperes, and for the single tank per phase type, 5000 amperes. The limit of interrupting duty for oil circuit breakers at present is about 2,000,000 kv-a. While larger breakers can be developed, their cost will be high, and so it is of considerable economic importance to keep the present standard sizes.

For this reason, the remainder of the table has been compiled on the basis of 4000-ampere breakers being used throughout. This considerably reduces the maximum kv-a. that can be transferred along the bus for cases I and II, as indicated by the eighth line of the table, unless additional breakers operated in parallel are employed, as shown by lines 6 and 7.

III. Conclusions and Acknowledgments

Consideration of the data presented in the paper leads to these conclusions.

1. The double winding generator can conveniently

be applied in large power stations, using any of the usual systems of bus connections, with resulting large advantages in reduced cost of equipment, lower fault currents, and more effective isolation of faults.

2. The best type of double winding for ordinary purposes is the split belt design, shown in Fig. 3. When ample generator reactor capacity is installed, however, the alternate slot type of winding may be preferable, due to its slightly lower stray losses, and less end winding magnetic forces with unequal loadings.

3. The principal limitations of the double winding generator, due to its low capacity for transfer of power along the bus, and the saturation of its "through" reactance, when excessive currents are transferred under fault conditions, are not usually of great importance. The former may generally be overcome by means of a balancing transformer, and the latter by the use of a reasonable amount of generator reactor capacity.

4. It is, therefore probable that the double winding generator will become the standard for future power stations, where units of very large size (over 100,000 kv-a.) are installed.

The authors acknowledge the material assistance rendered them by Mr. T. F. Barton, whose original thought led to the developments described, Messrs. R. H. Park and D. H. Harms, who contributed many helpful suggestions, and Mr. A. H. Wing, who managed most of the tests.

ILLUMINATION ITEMS

Submitted by
The Committee on Production and Application of Light

A NEW PORTABLE LIGHT INTENSITY METER

J. L. McCoy[1]

A new Light Intensity Meter has been developed to take advantage of the many desirable features of the photoelectric cell. With this meter, the intensity of the light at the point of test is indicated directly on a scale without the necessity of balancing against a standard comparison lamp.

The meter is a complete unit, carried in one case. The light sensitive pickup is a photoelectric cell covered with a shield, in the side of which a window is cut to admit the light to be measured. The photoelectric cell unit is connected to the meter by a 6-ft. cord, making it possible to move the cell anywhere within that radius without moving the meter case. The instrument contains a commercial, portable microammeter which is calibrated directly in terms of foot-candles. The energy required to operate the meter is furnished by the smallest size of "B" batteries mounted in the case, and the current consumed is so small as to be almost negligible. The life of the batteries in service is practically the same as their shelf life.

The photoelectric cell is somewhat similar in appearance to a radio tube and contains two essential parts,—an anode and a cathode. It is the cathode coated with light sensitive material that gives the tube its characteristics. There is a number of different types of photoelectric cells and their characteristics vary materially with the elements used for the cathodes. They can be made of different materials to respond to different wavelengths of light. One type of cell is in use which responds only to light of wavelengths beyond the visible spectrum in the ultra violet region.

Fig. 1—Light Intensity Meter

The scale is calibrated in foot-candles

The cell used in the Light Intensity Meter is a special one having a very broad response, covering the visible spectrum. When used in motion picture studios to measure the intensity of the illumination on the "sets," it is found that the response curve of the cell closely approaches the sensitivity of panchromatic film in combination with the light from Mazda lamps. The meter thereby enables the cameraman to determine definitely whether the illumination is sufficient for good photography. Other uses for the meter are being developed rapidly.

Electrical engineers appointed by the National Research Council recently met to discuss plans for the electrical part of the Chicago World's Fair of 1933 to commemorate the centenary of the city and the progress of the arts. As reported in the *Electrical World*, a "circular temple of electricity" was suggested, to be 600 ft. in diameter and divided into 32 theaters, the audiences being moved by mechanical means before as many stages, on which the important phases of electrical development would be shown. It is also planned to build large models of steam-electric and hydro-electric stations, including one of the State Line power house.

Thirteen prominent electrical engineers attended the meeting, R. F. Schuchardt, chairman of the committee in charge, presiding.

1. Vacuum Device Department, Westinghouse Lamp Company, Bloomfield, N. J.

Institute and Related Activities

The Coming Meeting at Springfield May 7-10

Interesting plans are rapidly nearing completion for the A. I. E. E. North Eastern District Meeting No. 1, to be held this year at Springfield, Massachusetts, May 7-10, 1930.

The program of technical papers will include the subjects of Instruments and Measurements, Transmission, Electrical Machinery with one session on specially selected subjects. The inspection trips, too, will be particularly worthy of note, as will be shown by the program to be published in the April issue, in which greater detail of all features of the meeting will be given, including the plans for the more diversive portions of the plans.

Scholarships in E. E. at Columbia

Each year the governing bodies of Columbia University have placed at the disposal of the Institute a scholarship in Electrical Engineering in the schools of Mines, Engineering, and Chemistry of Columbia University, for each class. The scholarship pays $350 toward the annual tuition fees which vary from $340 to $360, according to the details of the course selected. Reappointment of a student to the scholarship for the completion of his course is conditioned upon the maintenance of good standing in his work.

Applicants must meet the regular admission requirements, and all letters of application addressed to F. L. Hutchinson, the National Secretary, A. I. E. E., 33 West 39th St., should state age of candidate, place of birth, education, reference to any other activities, such as athletics or working one's way through college, references and photograph. The last day for filing applications for the year 1930-31 will be June 1, 1930.

The course at the Columbia School of Mines, Engineering, and Chemistry is a three year course on a graduate basis. Candidates must have had a general education, including considerable work in mathematics, physics, and chemistry. Three years of preparatory work with special attention to the three preparatory subjects mentioned in a good college or scientific school should be sufficient. A college graduate with a B. S. degree in engineering can generally qualify to advantage. The candidate is admitted on the basis of his previous collegiate record without undergoing special examination. Other qualifications being equal, members of Student Branches of the A. I. E. E. will be given preference.

The purpose of this advanced course is to produce a high type of engineer, trained in the humanities as well as in the fundamentals of his profession. It is hoped that Enrolled Students and others qualified will show a keen interest in this scholarship.

Research Graduate Assistantships

To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains 14 Research Graduate Assistantships in the Engineering Experiment Station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. For each of these there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees. Graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry are eligible.

An appointment to the position of Research Graduate Assistant is made and must be accepted for two consecutive collegiate years of ten months each, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Half of the time of a Research Graduate Assistant (approximately 900 clock hours for each ten-month period) is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study. Additional information may be obtained by addressing the Director of Engineering Experiment Station, University of Illinois, Urbana, Illinois.

Swiss Industries Fair

Again this year the old historical city of Basel will open its gates to the Swiss Industries Fair, to be held from April 26th to May 6th,—a central market for Swiss production where only Swiss high grade goods are exhibited. Each year the number of exhibitors increases, amounting now to well over a thousand, for products divided into several groups, *i. e.*, chemicals and pharmaceutical products; watches, clocks and jewelry; applied arts, pottery and china; machinery and tools; fine mechanical and precision instruments; textile goods, clothing and outfitting; footwear and leather-goods; paper and paper-goods; office fittings and appliances; etc., etc.

Free Information on Canada

For the benefit of members and friends of the Institute who contemplate attending the Summer Convention to be held in Toronto, Canada, June 23-27, 1930, information on Canada's recreational attractions may be had without charge from the Natural Resources Intelligence Service, Department of the Interior, at Ottawa, Canada.

This service also issues for free distribution a series of automobile road maps consisting of four sections, showing the highways in Canada and the northern states; namely, the Atlantic, Great Lakes, Middle West and Pacific Sheets.

STANDARDS

Standards for Insulator Tests

A Sectional Committee on Power Line Insulators for Voltage Exceeding 750, sponsored jointly by the National Electrical Manufacturers Association and the A. I. E. E. and organized in accordance with the procedure of the American Standards Association, has just completed the development of a proposed Standard for Insulator Tests and Ratings. This standard which is in the nature of a revision of A. I. E. E. Standard No. 41, "Insulator Test Specifications," has had the unanimous approval of the Sectional Committee and is now before the joint sponsors for action.

Electric Mine Locomotive Control Apparatus

Under date of December 18, 1929 the appointment of a joint sponsorship to develop American Standards for Electric Mine Locomotive Control Apparatus was approved. The sponsors designated are the National Electrical Manufacturers Association, the American Mining Congress and the A. I. E. E. The scope of the project as set up by American Standards Association will be as follows: Definitions, classifications, rating, methods of test for electric mine locomotive control apparatus.

The 1930 Winter Convention

MARKED BY HIGH QUALITY PAPERS, INCREASED ATTENDANCE AT SESSIONS AND EXCELLENT ENTERTAINMENT FEATURES

The Winter Conventions of the A. I. E. E. have constantly increased in importance as forums where current technical electrical engineering problems are presented and discussed, and the 1930 Convention fully maintained the prestige of these annual gatherings.

The total attendance was greater than that of last year, but the interest in the work of the convention is measured more accurately by the attendance at the technical sessions than by the total number registered, and the convention just closed was notable for the unusually large attendance and sustained interest at all the technical sessions.

The smoker and the dinner-dance, the two principal entertainment features were highly enjoyable affairs and were well attended, as were the various inspection trips to points of engineering interest. There were 130 ladies registered for whom a special program of entertainment was prepared, including visits to points of interest, shopping trips, bridge parties, afternoon teas, etc. These were all well attended and highly appreciated.

The chief objective of the Winter Convention, however, is the technical program, and fifty papers were presented and discussed in ten technical sessions. The papers covered a wide field of endeavor and included subjects of interest to the designer and operator of electric machinery as well as the research worker and abstract theorist. The vigorous discussions testified to the general interest with which the papers were received.

Monday, January 27

Protective Devices

The opening session, at 2:00 o'clock, was called to order by President H. B. Smith, who said that the calling of a great national convention meant not only the presentation of an accumulation of technical information to the membership of the Institute, but what is a more important feature, the strengthening and stimulating of acquaintanceships. He introduced Mr. A. E. Knowlton, Chairman of the Meetings and Papers Committee, who explained that the activities of the technical committees form a very good index of the interest and timeliness of engineering subjects and that the program had been chosen practically upon that basis, from a superabundance of papers nearly always on hand.

Chairman E. A. Hester, of the Protective Devices Committee, then took the chair and called for the presentation of the papers scheduled for this session which consisted of two groups; the first by Messrs. Slepian, Tanberg, and Kraus on *Development of a New Autovalve Lightning Arrester*, and the other by Mr. McEachron on *A New Metal for Lightning Arresters*.

The second group on oil circuit breakers included *Metal-Clad Switchgear at State Line Station* by Mr. Rossman, and *Extinction of a Long A-C. Arc* by Dr. Slepian, the latter showing the application of the deion principle to high-voltage oil breakers. The final paper, covering the practical application of this principle, was *Use of Oil in Arc Rupturing* by Messrs. Baker and Wilcox.

Ultra Violet Radiation

The evening session at 8:15 o'clock was a joint meeting with the Illuminating Engineering Society. Mr. G. S. Merrill called the meeting to order and nominated as presiding officer Mr. P. S. Millar who had rendered notable service to both organizations. The subject of the session, ultra violet rays, has assumed considerable importance in industry, in hygiene and in therapeutics during recent years. A variety of ultra violet radiators are now available, the latest development of which was described in the paper by Dr. Luckiesh entitled *Simulating Sunlight.* The next paper, dealing with the measurement of ultra violet radiation was presented by Dr. H. C. Rentschler, on *An Ultra Violet Light Meter.*

Tuesday, January 28

Power System Planning

This session, sponsored by the Committee on Power Generation, convened at 10 o'clock, with Mr. F. A. Allner, Chairman of the committee, presiding. The methods of planning for future growth in the Chicago, Detroit, and Philadelphia districts were described in three of the papers, and the other two related to operating problems; the effect of turbine governors on system stability, and the use of phase-shifting equipment for adjusting out-of-phase points of a connected network. The titles of these papers, which the discussors agreed were valuable contributions, were as follows:

System Connections and Interconnections in Chicago District, by G. M. Armbrust and T. G. LeClair; *Fundamental Plan of Power Supply in the Detroit District*, by S. M. Dean; *Fundamental Plan of Power Supply in the Philadelphia Area*, by Raymond Bailey; *Operating Characteristics of Turbine Governors*, by T. C. Purcell and A. P. Hayward; and *Controlling Power Flow with Phase-Shifting Equipment*, by W. J. Lyman.

Selected Subjects

The afternoon session was under the auspices of the Committee on Research and Mr. S. M. Kintner, Chairman of that committee, presided. The first paper by Dr. A. E. Kennelly on *The Units of the Magnetic Circuit* drew attention to some inconsistencies in the present magnetic units and proposed some revisions which were indorsed in several communicated and verbal discussions. The next two papers, on *The Calculation of Induced Voltages in Metallic Conductors*, by H. B. Dwight, and *Induced Voltages of Electrical Machines*, by L. V. Bewley, considered the theory of induced voltages in conductors and windings. The last paper of the session, by Mr. O. Ackermann, described *A Cathode Ray Oscillograph with Norinder Relay* which is self-starting on the impulse of the recorded surge. Considerable discussion ensued as to the most convenient type of apparatus for recording surges.

The Smoker

On Tuesday evening the annual dinner-smoker was held and proved a most popular and enjoyable affair which filled the Auditorium to capacity. An excellent buffet dinner was served by Louis Sherry in the fifth floor assembly rooms, and the interim between the dinner and the entertainment beginning at 8:15 p. m. was devoted to a series of moving pictures shown in the Auditorium. Mr. H. A. Kidder then introduced Mr. Phillips Carlin, the well-known radio announcer, who acted as Master of Ceremonies. There were six entertainment numbers presented through the courtesy of the Radio Corporation of America, General Cable Co., National Broadcasting Co., American Steel and Wire Co., Pathé Exchange, Inc., and others. Mr. Carlin's introductions and remarks and the excellent performances of the artists resulted in a most enjoyable evening punctuated with frequent laughter and applause.

Wednesday, January 29

Lightning Investigations

Under the auspices of the Committee on Power Transmission and Distribution, eight papers on lightning investigations were presented and discussed at the session on Wednesday morning, with Mr. H. R. Woodrow, Chairman of the committee, in the chair. These papers represent a concerted attack on the part of

various manufacturers and central station companies during 1929 to investigate the nature of lightning and method of protecting transmission lines from lightning surges. The papers were as follows:

Lightning on Transmission Lines, by J. H. Cox and Edward Beck; *Surge Characteristics of Insulators and Gaps*, by J. J. Torok; *Lightning Investigations on Lines of Public Service Electric & Gas Co.*, by R. N. Conwell and C. L. Fortescue; *Lightning Voltages on Transmission Lines*, by R. H. George and J. R. Eaton; *Traveling Waves on Transmission Lines with Artificial Lightning Surges*, by K. B. McEachron, W. J. Rudge, and J. G. Hemstreet; *Lightning Investigation on 220-Kv. System of Pennsylvania Power and Light Co.*, by Nicholas N. Smeloff and A. L. Price; *Lightning Investigation on Ohio Power Co's. 132-Kv. System*, by Philip Sporn and W. L. Lloyd, Jr.; *Lightning Investigation on Transmission Lines*, by W. W. Lewis and C. M. Foust.

The discussion of these papers was thorough and prolonged and extended into a special session on Thursday morning.

Inspection Trips

Wednesday afternoon was set apart for visits to places of engineering interest and no technical session was scheduled for this period. The six special trips listed for Wednesday afternoon were as follows:

1. Roseland Switching Station, Public Service Electric and Gas Company. 2. Aeroplane Factory, Fokker Aircraft Corporation, Passaic and Teeterboro, New Jersey. 3. Demonstration of latest equipment at the Bell Telephone Laboratories. 4. The Sperry Gyroscope Corporation and Air Map Corporation of America, Brooklyn. 5. Short-Wave Transatlantic Radio Transmitting Station of American Telephone and Telegraph Company, at Lawrenceville, New Jersey. 6. Transatlantic Cable Terminal, International Telephone and Telegraph Company, 67 Broad Street, New York, N. Y.

The above trips were restricted to Wednesday afternoon and were very largely patronized. In addition to these, there were ten other inspection trips to central stations and engineering works which were visited daily during the convention at specified hours. Tickets were issued without charge for all inspection trips, and for many of the trips, free transportation from headquarters was furnished.

Directors Meeting

A meeting of the Board of Directors of the A. I. E. E. was held at 1:30 p. m. at Institute headquarters. A résumé of the business transacted at this meeting will be found elsewhere in this issue of the Journal.

Edison Medal Presentation

The presentation of the Edison Medal to Charles F. Scott was made in the Engineering Auditorium at 8:30 p. m. The ceremony included an address by Past-President L. B. Stillwell, the presentation of the Medal by President H. B. Smith, and the response of the medallist, Charles F. Scott. A detailed account of the ceremony is printed elsewhere in this issue of the Journal.

Lecture

A brief recess was taken at the close of the Edison Medal presentation, following which Dr. David M. Robinson delivered a lecture on "Discovery and Excavation at Olynthos."

Thursday, January 30

Transoceanic Communication

The session on Transoceanic Communication was held Thursday morning at 10:00 o'clock under the auspices of the Committee on Communication, with Mr. H. S. Osborne, Vice-Chairman of the committee in the chair. Mr. Osborne spoke briefly concerning the change that transoceanic telephony has wrought in the relations between nations and the reaction upon human life—a change that we have probably only begun to realize at the present time. He then called for the presentation of the papers which were entitled,

Submarine Telegraphy in the Post-War Decade, by I. S. Coggeshall; *Transoceanic Telephone Service—General Aspects*, by T. G. Miller; *Transoceanic Telephone Service—Short-Wave Transmission*, by Ralph Bown; *Transoceanic Telephone Service—Short-Wave Equipment*, by A. A. Oswald; *Transoceanic Telephone Service—Short-Wave Stations*, by F. A. Cowan.

It was brought out that from any part of the United States or Canada it is now possible to communicate with about 85 per cent of all the telephones in the world. When the remaining connections are made, there will still be other problems to be solved, not all of an engineering nature. Certain limitations are imposed by the difference in time of distant places and also by difference in languages.

Welding

Two sessions were held in parallel Thursday afternoon, Session A on Welding and Session B on Dielectrics. The session on welding was called to order at 2:00 o'clock by Chairman A. M. Candy, of the Committee on Electric Welding. Five papers were presented covering both theoretical and practical aspects of electric welding, the titles being as follows:

Cathode Energy of the Iron Arc, by G. E. Doan; *Calorimetric Study of the Arc*, by P. P. Alexander; *Resistance Welding*, by B. T. Mottinger; *Electrically Welded Structures under Dynamic Stress*, by Morris Stone and J. G. Ritter; *Electric Welding by Carbon Arc*, by J. C. Lincoln.

Much of the discussion hinged upon the various phenomena that take place in the electric arc, and it was felt that while such investigations are still very incomplete their ultimate solution may lead to radical improvements in the practical art of welding.

Dielectrics

Session B on Dielectrics was held in the Auditorium at 2:00 o'clock. With Mr. O. E. Buckley, Chairman of the Committee on Electrophysics presiding. As pointed out by the chairman, the five papers all came from universities where research work is being carried on under the direction of the authors. The papers were entitled as follows:

Conductivity of Insulating Oils, by J. B. Whitehead and R. H. Marvin; *Behavior of Dielectrics*, by R. R. Benedict; *Three Regions of Dielectric Breakdown*, by P. H. Moon and A. S. Norcross; *Ionization Studies in Paper-Insulated Cables—III*, by C. L. Dawes and P. H. Humphries; *High-Voltage Corona in Air*, by S. K. Waldorf.

Both the papers and discussion disclosed the most recent research in the field of dielectric phenomena in air, oil, and paper insulation.

Dinner-Dance

The annual Winter Convention dinner-dance has grown in popularity and attendance with each succeeding year until it has become the major social event of the Institute. It was held this year in the Grand Ballroom of the Hotel Astor at 7:30 o'clock Thursday evening. About 750 members and guests attended and after the tables were cleared away a most enjoyable evening of dancing followed to the excellent dance music of the "Venetian Gondoliers."

Friday, January 31

Electrical Machinery

The final day of the Convention was devoted to two sessions under the auspices of the Committee on Electrical Machinery. The morning session, under the chairmanship of Mr. P. L. Alger, was convened at 10:00 o'clock and all of the papers for this session dealt with operating problems. The titles of the papers follow:

Loading Transformers by Temperature, by V. M. Montsinger; *Operating Transformers by Temperature*, by W. M. Dann; *Tap Changing Under Load for Voltage and Phase-Angle Control*, by H. B. West; *Telephone Interference from A-C. Generators Feeding Directly on Line with Neutral Grounded*, by J. J. Smith; *Inversion Currents and Voltages in Autotransformers*, by A. Boyajian.

The afternoon session on the same general subject was opened at 2:00 o'clock, Mr. P. L. Alger presiding. The afternoon program was devoted entirely to papers on design problems, the titles of which are as follows:

Generalized Theory of Electrical Machinery, by Gabriel Kron; *Quiet Induction Motors*, by L. E. Hildebrand; *Transient Torque-Angle Characteristics of Synchronous Machines*, by W. V. Lyon and H. E. Edgerton; *Starting Performance of Salient-Pole Synchronous Motors*, by T. M. Linville; *Ventilation of Revolving-Field Salient-Pole Alternators*, by C. J. Fechheimer; *Synchronous Machines, V, (Three-Phase Short Circuit)*, by R. E. Doherty and C. A. Nickle.

The last paper of the session was presented by title only and was not discussed at the meeting. The other papers called forth very complete discussions which were so voluminous that no attempt has been made to summarize them here. They will be printed in full in subsequent issues of the QUARTERLY TRANSACTIONS.

The session on Friday afternoon brought to a conclusion what was from both a social and a technical standpoint a most enjoyable and profitable convention.

Much of the success of the convention is due to the excellent work of the committees in charge of the arrangements, including the General Committee, H. P. Charlesworth, Chairman; Entertainment Committee, J. B. Bassett, Chairman; Smoker Committee, G. J. Read, Chairman; Inspection Trip Committee, F. Zogbaum, Chairman; Dinner-Dance Committee, C. R. Jones, Chairman; Ladies Committee, Mrs. G. L. Knight, Chairman.

A. I. E. E. Directors Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, on Wednesday, January 29, 1930.

There were present: President Harold B. Smith, Worcester, Mass.; Past Presidents Bancroft Gherardi, New York, N. Y., and R. F. Schuchardt, Chicago, Ill.; Vice-Presidents E. B. Merriam, Schenectady, N. Y.; H. A. Kidder, New York, N. Y.; B. D. Hull, Dallas, Tex.; Herbert S. Evans, Boulder, Colo.; W. S. Rodman, University, Va.; E. C. Stone, Pittsburgh, Pa.; and C. E. Sisson, Toronto, Canada; Directors I. E. Moultrop, Boston, Mass.; H. C. Don Carlos, Toronto, Canada; F. J. Chesterman, Philadelphia, Pa.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; J. Allen Johnson, Buffalo, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; W. S. Lee, Charlotte, N. C.; J. E. Kearns, Chicago, Ill.; C. E. Stephens, New York, N. Y.; National Secretary F. L. Hutchinson, New York, N. Y.

The following minute was adopted in memory of the late Dr. S. Z. de Ferranti, Honorary Member of the A. I. E. E.:

The Board of Directors of the American Institute of Electrical Engineers desires to record in its minutes a tribute to the memory of Dr. Sebastian Ziani de Ferranti, a member of the Institute since 1903 and Honorary Member since 1912, who died on January 13, 1930.

Dr. de Ferranti, a man of delightful personality, was an outstanding pioneer in engineering, having begun work in this field at the age of about thirteen, and made important developments in several types of electrical equipment while very young. He was one of the first to propose high-voltage transmission of power, and his achievements in the development of the necessary equipment, as well as other electrical apparatus, are widely known and appreciated. During his entire career of continual effort and accomplishment, he exhibited marked ability as an inventor, a designer, and a manufacturer, which won him an international reputation.

It is, therefore, with a sincere appreciation of the great loss sustained by the engineering profession and the Institute that the Board of Directors hereby extends deepest sympathy to his family and associates.

A report was presented of a meeting of the Board of Examiners held December 11, 1929, and the actions taken at that meeting were approved. Upon the recommendation of the Board of Examiners, the following actions were taken: 807 Students were enrolled; 257 applicants were elected to the grade of Associate; 13 applicants were elected to the grade of Member; one applicant was elected to the grade of Fellow; 21 applicants were transferred to the grade of Member; and three applicants were transferred to the grade of Fellow.

The Board ratified approval by the Finance Committee for payment, of monthly bills amounting to $28,377.24.

As required by the By-laws, a resolution was adopted specifying the date and location of the 1930 Annual Meeting of the Institute, namely, Monday, June 23, at Toronto, Ontario, during the Annual Summer Convention of the Institute.

Approval was given to the dates, October 13-15, 1930, selected by the officers of the Philadelphia Section and of the Middle Eastern District for the already authorized District meeting at Philadelphia.

By-law 58 was amended by the addition of the following paragraph:

"The Board of Directors may at any time terminate the existence of any Student Branch when in its judgment the interests of the Institute make such action desirable."

This amendment was made because the Constitution provides that Sections and Branches may be discontinued by action of the Board of Directors as provided in the By-laws, and the By-laws formerly provided for the termination of the existence of Sections but not of Student Branches.

Approval was given to amendments to the By-laws (Secs. 1, 3, and 4 of Article VI) of the Lamme Medal Committee, changing the time for the receipt of nominations and for the consideration of the achievements of the candidates.

Mr. Renzo Norsa, Managing Director, Compagnia Generale di Elettricità, Milan, was appointed Local Honorary Secretary of the Institute for Italy, to succeed Guido Semenza, deceased.

It was voted to establish with the South African Institute of Electrical Engineers, reciprocal arrangements for the exchange of membership privileges for visiting members, similar to the arrangements that have been made in the past with other foreign engineering societies.

The Annual Report of the President of the U. S. National Committee of the International Commission on Illumination was received, and payment was authorized of the 1930 subscription of $300 to the Committee.

A report of the Special Committee on Transfer of Enrolled Students to the Grade of Associate was presented, and the recommendations of the Committee were approved, as covered elsewhere in this issue.

Proposed amendments to the Constitution were considered and approved for submission to the membership for letter ballot.

Upon the recommendation of the Standards Committee, approval was given to a revision in the American Standard for Aeronautical Symbols, made by the Sectional Committee on Scientific and Engineering Symbols and Abbreviations, and Underwriters' Laboratories' Specifications for "Flexible Cord" and for "Panelboards" were approved with the understanding that they are subject to reconsideration should any serious objection to them be raised by any of the groups having a major interest in the subject matter of the specifications.

The Standards Committee presented a proposal to unify and simplify procedure in electrical standardization; and the recommendations of the Committee in this connection were approved, as explained elsewhere in this issue.

An invitation to be officially represented at the Semi-Centennial of the University of Southern California, June 4-6, 1930, at Los Angeles, California, was referred to the President with power to appoint a representative.

Others matters were discussed, reference to which may be found in this and future issues of the JOURNAL.

Edison Medal Presented to Charles F. Scott

Wednesday evening, January 29th, the Edison Medal was presented to Charles F. Scott in the Engineering Auditorium, New York, President Harold B. Smith presiding. In order that the audience might have a full appreciation of the occasion President Smith called upon National Secretary Hutchinson to explain the origin and significance of the Edison Medal.

After a brief outline of the history of the medal by Secretary Hutchinson, President Smith called upon Past President L. B. Stillwell, who was for many years closely associated with the medalist, to tell of some of the work and accomplishments of Professor Scott leading up to his present recognition as medalist.

Mr. Stillwell gave an interesting account of Professor Scott's early work in the Westinghouse Company in connection with the development of the polyphase motor and the a-c. systems of distribution. The four-year period ending with the year 1892 was a very busy time for the engineering department of the company as the polyphase system for commercial service was then first developed for two-phase, 60-cycle and 30-cycle apparatus.

Mr. Scott's part in the revolutionary development of this four-year period was an important one and his work contributed in a large measure to the successful results obtained.

Concerning the development of the Scott connection for transformers, Mr. Stillwell related the following incident:

"In 1892, I was preparing plans and estimates as the basis for a tender by the Company covering the transmission of several thousand kilowatts from Folsom, California to Sacramento. I knew that the General Electric Company would figure on three-phase transmission, which meant three instead of four conductors and involved a difference of $12,000 in cost of copper for the transmission circuit. I called in Scott and showed him the situation. We discussed it briefly and he expressed the opinion that the problem could be solved. Then he withdrew to another office, and within a remarkably short time returned with his two-phase, three-phase connection of transformers—a perfect solution. In the light of present day knowledge, this, may not seem remarkable, but, in 1892, few were competent to deal promptly with problems of this type and the incident illustrates admirably Scott's ability in applying theory to practical problems."

Mr. Stillwell, in conclusion, summarized Mr. Scott's professional activities as follows:

"As I have stated, he entered the employ of the Westinghouse Company in the summer of 1888 and the record of his rapid advancement is eloquent testimony to his accomplishments.

"In 1891, he became Assist Electrician and in 1897 Chief Electrician. In 1904, he was appointed Consulting Engineer to the Company, a position which he still holds.

"As President of this Institute, his administration was a brilliant success. The activities of the Institute were widely extended by the adoption of a systematic plan of holding local meetings.

"Mr. Carnegie's munificent gift to the Engineering Societies of the building in which this meeting is held was very largely due to his initiative and effort.

"Always interested in engineering education, he accepted in 1911 the position of Professor of Electrical Engineering at Yale University which he still occupies.

"His highly successful services as President of the Society for the Promotion of Engineering Education from 1921 to 1923 are additional testimony to his versatile ability and great service to the engineering profession."

At the conclusion of Mr. Stillwell's remarks, President Smith presented the Medal to Professor Scott, whose response was as follows:

Response of Charles F. Scott on Receiving the Edison Medal

In our recent National Celebration of Light's Golden Jubilee we commemorated a great achievement of the electrical pioneer in whose honor the Edison Medal was founded.

That achievement was the inauguration of the practical electric light,—the beginning of modern electric power service.

To appreciate just what Edison did we must know the background. A few years earlier the Centennial Exposition in Philadelphia followed a century of political independence and a century of the steam engine of Watt, the two great factors in developing America. And the outstanding exhibit was the monster Corliss engine, an engine of a thousand horse-power, gigantic product of the steam-power century. At the Exposition also were the beginnings of a twin romance; one, the telephone of Bell, Edison Medalist, an almost overlooked scientific curiosity, but now the means by which the King of England may broadcast a message of peace to the whole world; the other a dynamo supplying current to an arc lamp which fired the interest and shaped the career of young Elihu Thomson, first recipient of the Edison Medal.

The pigmy dynamo grew; in a few decades it exceeded in capacity the largest Corliss engine; then it commandeered the steam turbine which now exceeds the power of the great Centennial engine by a hundredfold.

Steps in Evolution of Electric Power

But in the early years the pressing problem was to make things smaller, not larger. It was the subdivision of the electric light. The brilliant arc lamp was unsuited to indoor lighting. The incandescent lamp was promising but its large filament required a large current and the series system adapted for arc lamps in streets was unsuited to indoor use. Edison recognized that to compete with gas, lamps should be in parallel; also that the current of the individual lamp must be very small or the aggregate current of many lamps would require a conductor of inordinate size. The quest for a threadlike conductor or filament was not for the lamp itself but to adapt it to a practicable circuit. And presently came the triumph, the hundred volt lamp and parallel operation from a central station, inaugurating the distribution and sale of electric energy. But the cost of the circuit was still the limitation. Even with recourse to the three-wire method and Edison's development of the feeder main system, the economic limit proved to be less than a mile.

Then came a second great step in electric service, the alternating current. Small currents in high-tension wires could be carried great distances and then changed by transformers to large currents wherever required. Introduced commercially it gave great impetus to incandescent lighting. But while the Edison direct current system could furnish motor service, there was no motor for the alternating or "Westinghouse" current.

Then came the outstanding contribution of Nikola Tesla, 7th Edison Medalist, to electric power service revealed through patents of May 1, 1888, for the induction motor and the polyphase system. The induction motor in itself ideally simple, called for alternating currents differing in phase much as the motions of pistons which act successively on the angularly placed cranks of a locomotive or of an automobile. At first there was hope that the new motor could in some way be operated from the existing single phase lighting circuits; but for satisfactory operation it demanded polyphase circuits and lower frequency. Electric lighting companies hesitated before re-equipping their stations to supply an auxiliary motor service. And the motor did not achieve its large distinction as a mere supplement to lighting but in a new field of its own creation. Consider the various types of electric service then in use. Arc lighting required a separate generator and circuit for each group of 50 or 100 lamps. Incandescent lighting was supplied either by direct current so limited in radius that many stations were required for lighting a city or by single phase alternators which were not operated in parallel but each supplied its own circuits. Electric railways and larger power service required their own types of generating machinery. A flourishing New England central station of 1000 kw. had 24 machines of 5 types and more than a score of outgoing independent circuits.

Then came a great event. The outstanding power development of the world was projected at Niagara Falls. It contemplated the production of many times the power that had been produced in any single locality and the transmission of this power over a wide area. In 1890 the International Niagara Commission sought proposals on methods. Hydraulic methods, compressed air, and direct current had many advocates while Professor Forbes alone proposed the polyphase system, at that time undeveloped for so large an enterprise. Nothing seemed adequate. But within a few years the polyphase exhibit at the Chicago World's Fair in 1893 showed the development of apparatus and the possibilities of the system. The polyphase system was adopted for Niagara. It enabled electric service of all kinds to be supplied from one source. The multiplicity of small machines and the prevalent heterogeneous systems and circuits were replaced by one comprehensive system for universal service.

The pioneer plan inaugurated at Niagara has been followed and the power systems of the world today and those planning for the future employ the polyphase alternating current. Large generators, operating in parallel in the same station and in remote stations, transmission over great distances and the conversion and transformation of current suitable for all purposes makes this the universal system. There is no other known method by which our present extended use of electric power would have been possible.

The three great engineering steps in the commercial evolution of electric power were inaugurated by the direct current Pearl Street Station in 1882; second, the single phase alternating current service in 1886 and third, the

polyphase alternating current system on an outstanding scale by the Niagara plant in 1895.

The steam engine, although limited in its capabilities to mechanical drive within the limited area reached by shafting and belt, created the industrial revolution and made the progress of the nineteenth century outstanding.

What Electricity Does for Men

Electricity liberates power; it transmits the power produced by steam or falling water over great distances, subdivides it for the dentist's drill and the gigantic steel mill, transforms it into light for changing night into day, supplies heat for making toast and melting steel and creates new materials by the alchemy of electro-metallurgy; and everywhere serves with safety and convenience in application and control.

Muscular power which did the work of the world for untold ages was replaced by the mighty power of the engine in the last century and now in our twentieth century electricity makes the power of the engine tenfold more effective.

At first electricity did the old things in about the same way. The early incandescent lamps differed little in quantity or quality of light from the gas jet. The electrician usually replaced a gas jet by a lamp. The light was steady; the open flame and vitiation of the air disappeared and remote switching was a convenience, but the illumination was of the same order. The illuminating engineer and the art of electric illumination came later with the Tungsten lamp used in new ways to transform the darkness of night into brilliance and splendor. And incandescent lamps in the year of the Golden Jubilee produce some 50 times the illumination that they did at the end of their first 25 years.

The electric motor in industry at first replaced the engine for driving a shaft; emphasis was on the power system, the motor was merely a convenient and economical substitute for the engine. Then came individual drive and speed control. Then machine tools were made stronger and were operated at higher speed; the motor and the machine were designed as a single mechanical unit; tools were modified to take advantage of unlimited power, speed adjustment and automatic control, with large emphasis on the latter.

Recently a large steel mill was electrified. To replace the reversing engine by a motor would have been a simple matter. But, the whole mill was redesigned and rebuilt at a cost of many millions of dollars to secure the advantages made possible by electric power and automatic control, for securing better product and larger output at less cost.

Now it is proposed to make a radical innovation; instead of connecting the upper and lower rolls by massive gears, they will be operated by individual motors, concurrently controlled.

Electricity in industry is being viewed from a new angle, not how to apply it to aid here and overcome a difficulty somewhere else, but what it is possible to accomplish by 100 per cent electrification.

Electricity goes further; not only is it an agency which men direct and control but electricity itself is assuming the function of supervisory control. The automatic telephone exchange is taking the place of telephone operators and in the automatic power house and substation electric devices supplant station operators for starting and putting machines in service when needed, and vice versa.

In the textile industry the empty bobbin is automatically replaced and the broken thread of the loom, once the responsibility of the weaver to detect, now electrically stops the loom. We live in a machine age.

Electric motors do the work of arm and hand, and now the electric eye and the electric ear, and seeming electric intelligence supervise and control. The things that machines and power now do are beyond the imagination of the past generation. We scarcely comprehend them ourselves but yet the advance is going on. The output of our power stations in 1929 exceeded that of the first thirty years of electric power service. A billion dollars a year provides for increased service.

And electric power is simply a means of doing useful things, and the measure of its value must be reckoned not merely in terms of its quantity but also in its superior quality.

Its Benefit to Society

But of greater significance is the effect of power in industry upon the workers. Electricity adds a thrilling chapter to the story which began when the steam engine replaced muscular power.

In Andrew Carnegie's story of his boyhood, he says "The change from hand-loom to power-loom weaving was disastrous to our family. My father did not recognize the impending revolution and was struggling under the old system." And in the next paragraph he remarks, "I remember that shortly after this I began to learn what poverty meant." The engine drove the family to America and by a strange irony young Andy soon had a job running an engine. Later on his thousands of workers and big engines rolled steel for railroads and bridges and buildings for making our modern world. And it enabled him to become a millionaire benefactor and donor of this home of the engineering societies, agencies for contributing to human welfare.

Yes, mechanized industry has profoundly affected the workers. In pioneer days our forefathers worked long hours in the struggle for the bare necessities of life. With power and machinery these necessities are now produced by a quarter of the workers; others produce conveniences and luxuries. The economic problem has shifted from production to distribution and consumption. More efficient machines require fewer workers, shorter hours. As changes come, unemployment often results until there is readjustment in new industries.

For the first time in history our machine production creates an abundance which makes it possible to eliminate poverty.

Electricity in the home removes drudgery and makes for convenience in a dozen ways, light and power, heat and cold, telephone and radio.

Fewer working hours in industry and in the home give more leisure. It is estimated that America spends annually twenty billion dollars for play, half of which utilizes machines, automobiles, moving pictures, radio and the like.

Never before was universal education accepted as the right of all. The necessity for child labor is eliminated and greater wealth makes higher education practicable for many.

In these kaleidoscopic changes in which machinery and electric power in the factory, the home and on the farm is revolutionizing the methods of our industrial, economic and social life, the real wonder is not the changing physical scene but the readiness with which human nature accepts and adapts itself to these changes. For unknown centuries the ideal was conformity to tradition. New ideas and new methods often met with prison or decapitation. Now scientific research and invention make change inevitable and normal and they are accepted as a matter of course. New and far-reaching problems are encountered on every hand. The larger problems of electric power confound the statesman. The engineer makes possible the economies of superpower and in its wake come problems of ownership and control, involving the division of functions between the Nation and the States. At this very time a foremost problem of the Empire State is how to proceed legally with the development of its wasting water power.

It is the human relations that are most difficult of readjustment.

While the industrial revolution of a century ago brought great changes in production and in the general welfare it ruthlessly sacrificed the interests and the welfare of the workers. In the industrial activities of today health and safety, and welfare are looked after as never before. The ideal of wages has changed. It is not cheap labor but high wages that raise the standard of living and make workers consumers in the new economic circle of production and consumption. But again, we may overlook ultimate ends, and not give a fair answer to the question what it is all about; are we merely mechanizing the whole of life?

The Future

There is a great concern about the trend of our civilization. It is a prolific topic of magazine articles and learned books. That there are profound changes, all are agreed, not only as to industrial, economic, social, governmental and international relations, but also as to the very basis of morals and the place of religion in life. One writer points out the difficulties in applying the moral code evolved through centuries of rural life to the industrial city. He finds the economic independence of woman followed by her political independence a matter of great moment in readjustment of social relations and home life. He then states that the basic cause of our moral revolution was the industrial revolution.

Another keen student of personnel relations says electricity in industry is causing changes in personnel relations, in the number of workers, in type of work, and in the inter-relations between supervisors and workers, comparable to those which the steam engine produced through the industrial revolution of a century ago. Without realizing it we are in the midst of a new industrial and social revolution. Surely the prophetic engineer, George S. Morison, spoke truly when he said the steam engine was the beginning of a new epoch in civilization.

Pessimists predict that like Frankenstein we have built a monster which will destroy us. But surely the ability which has produced the machine civilization of the Western World is capable of realizing its unlimited opportunities.

Herbert Hoover on assuming the presidency of American Engineering Council nine years ago pointed out the new standards of living incident to our industrial civilization. He also indicated certain threatening faults such as unemployment, labor friction and turnover, the ebb and flow of economic tides between booms and slumps and other factors entailing distress or reducing productivity. He recommended that engineers undertake the task of finding the facts, of analysing the difficulties and proposing remedies. Then followed the notable investigation and the report upon "Waste in Industry."

As Secretary of Commerce, he inaugurated remedial measures by constructive action leading to simplification in methods and products and to stabilization of employment. And as President he seeks the rational solution of our National problems. He himself has followed the injunction given to his fellow engineers a few weeks before he entered the Cabinet.

"The spirit of cooperation that has been growing in our country during the last thirty years has already solved many things; it has standardized some things and is ripe for initiative toward cooperation of a wide spread character. The leadership of our Federal government in bringing together the forces is needed. No greater field of service exists than the stimulation of such cooperation. The first step is sane analysis of weakness and sober proposal of remedy. If the facts can be established to an intelligent people such as ours, action is certain even if it be slow. Our engineers are in unique position for this service and it is your obligation to carry it forward."

Transfer of Enrolled Students to Grade of Associate

During the Conferences of Officers and Delegates at the 1928 and 1929 Summer Conventions and at other meetings there has been much discussion of the desirability of permitting Enrolled Students of the Institute to be admitted as Associates without the full payment of $10.00 entrance fee and $10.00 dues for the first year.

A recommendation made at the 1929 Conference of Officers and Delegates was approved in principle by the Board of Directors at its meeting held on June 25, 1929, and referred to the incoming administration.

Early in August 1929, the President appointed a special committee to study all phases of the questions involved and to make recommendations to the Board, including the phraseology of the necessary amendments to the Constitution and By-laws. The committee was composed as follows: E. S. Lee, Chairman, Edward Bennett, H. H. Henline, B. D. Hull, A. E. Knowlton, E. B. Meyer, and L. F. Morehouse.

After many variations of the plans previously suggested had been carefully considered with respect to their suitability from the Students' standpoint, and their probable effects upon Institute finances, the special committee recommended a plan containing the provisions summarized in the following paragraph.

A student of a school of recognized standing may be enrolled as a Student of the A. I. E. E. (see Sec. 51 of the By-laws) throughout his graduate and undergraduate studies, upon payment of $3.00 per year, based upon the fiscal year of the Institute beginning May 1. The initial payment upon application for enrolment shall be on the basis of a full year's fee, three dollars ($3.00), or a half year's fee, one dollar and fifty cents ($1.50), depending upon whether the application is filed nearer to May 1 or November 1, respectively. The term of Student enrolment shall not extend beyond the end of the *fiscal year* in which the student graduates or leaves school. An Enrolled Student who applies for admission as an Associate before March 1 of the last fiscal year of his enrolment, and is elected, would not be required to pay the $10.00 entrance fee, but would pay the first year's dues of $10.00 dating from the following May 1. It was recommended that the enrolment of Students be placed on the basis of the fiscal year in order to provide more definitely for continuity of connections with the Institute.

At the meeting of the Board of Directors held on January 29, 1930, this plan and the proposed amendments to the Constitution necessary to place it in effect were approved. In accordance with the requirements of the Constitution, these amendments will be submitted to a vote of the membership, and the results will be reported at the Annual Business Meeting in Toronto, June 23, 1930. Amendments to the Constitution adopted at that time will take effect thirty days later.

The Board of Directors adopted a resolution extending the privilege of being admitted, without payment of the entrance fee, to any Students enrolled in the Institute at the time the amendments to the Constitution become effective, provided their applications for admission as Associates are received at Institute headquarters before the expiration of their enrolment under the present By-laws, and they are elected in accordance with the usual procedure.

Although it is hoped that the recommended plan will, if adopted, enable many young men who would find it difficult to meet the present cost of admission to the Associate grade to continue their connection with the Institute, the committee emphasized the facts that the recommended plan can supply only in part the incentives required for best results, and the degree of effectiveness will depend materially upon:

1. The conduct of Branch work in such a manner as to develop genuine interest in the objects and activities of the Institute.

2. Opportunities for recent graduates to participate in Section activities in order that their interest may be maintained and suitable experience may be gained.

AMERICAN ENGINEERING COUNCIL

NATIONAL HYDRAULIC LABORATORY

Senate Bill 3043 and H. R. 8299 providing for the establishment of a National Hydraulic Research Laboratory in the Bureau of Standards has again been introduced into the present Congress. In the Senate it was referred to the Committee on Commerce which promptly reported the bill out, and it is now on the calendar. Unquestionably it will be acted upon shortly after the Senate disposes of the Tariff Bill. In the house, it was referred to the Rivers and Harbors Committee, which called upon Major General Lytle Brown, the new Chief of Engineers, for a statement on the bill. General Brown appeared before the Committee on February 4 and stated that there was need for such a national hydraulic laboratory as indicated by the bill. He also stated that although he believed the Corps of Engineers needed data from such a laboratory perhaps as much as any other agency of the Government, there were other agencies that also required much more data than now available on the subject of hydraulics.

The Bill now has the endorsement of all governmental departments and agencies primarily concerned with hydraulic engineering of the Federal Government; namely, Bureau of Public Roads of the Department of Agriculture; Bureau of Standards of the Department of Commerce; Water Resources Division of the U. S. Geological Survey; Reclamation Service of the Department of Interior; and Corps of Engineers of the War Department. It was also approved by President Hoover when he was Secretary of Commerce.

American Engineering Council for a number of years has worked constantly for this measure and it appears that in this session of Congress it will be passed.

CRAMTON PATENT BILL

A bill known as the Cramton Bill, H. R. 699, to prevent fraud, deception, or improper practise in connection with business before the United States Patent Office, has been before the last two sessions of Congress.

Council has always been interested in matters designed to aid the Patent Office, and has consistently supported all measures intended to bring about the improvement in its operation. In presenting the engineers' views before the House Committee on Patents, the Executive Secretary stated that Council was in full sympathy with the purpose of the bill, but as it is now drafted, there are certain features that should be changed, for should the bill in its present form be passed, it would seriously interfere with the legitimate and constructive work done by men of science in connection with the preparation of the applications for patents. This can be very easily avoided by slight amendment already suggested.

NEMA Organizes Flood Lighting Section

At a conference held January 21 at the Westinghouse Lighting Institute in New York, further steps were taken to organize a Flood & Airport Lighting Section of the National Electrical Manufacturers Association. Nine manufacturers were represented and officers were elected as follows: Chairman, J. C. Herron of the Reflector and Illuminating Company and Secretary, W. H. Robinson, Jr. of the General Electric Company. The meeting carried further the proposals made in Detroit, December 19th, when a number of manufacturers' representatives started the organization of the proposed Section.

Plans were made for the future work of the Section, including the preparation of standards and the collection of statistics. It was decided to appoint two standardization committees, one for airport lighting and the other for all other types of flood lighting. Standardization of wattage ratings and standard specifications for illumination will be referred to both committees. The Airport Lighting Committee will be requested to review the Department of Commerce Specifications on this subject.

Work of Water Resources Division

The Water Resources Division of the U. S. Geological Survey will obtain through action of Congress $510,000—an increase of over 100 per cent. This means that all cooperative states will receive assistance from the Federal Government on a dollar-for-dollar basis, which is of great significance to the engineering profession and the country at large.

Topographic Surveys

The appropriation for topographic surveys for next year will be about one million dollars, which is many times larger than ever before. This will be increased yearly so that the topographic survey of the United States may be completed in 18 years instead of in from 80 to 100 years as would be the case under the old program. This means employment of a large number of engineers; and even those not employed will benefit with the availability of adequate topographic maps.

Increased Forest Service

For the Forest Service there is planned an increase of three and a quarter million dollars. A large share of this increase will be devoted to carrying out the national forestry research program authorized by the McNary and McSweeney Acts passed by the last Congress. To any engineer it is obvious what such an enlarged program will mean to the profession and to the public at large.

ENGINEERING FOUNDATION

EXTRACTS FROM PRESIDENT'S REPORT FOR 1929

United Engineering Society changed its name to Engineering Foundation, Inc. becoming effective 1st January 1930. (See February JOURNAL, page 152).

The Endowment Committee has continued its endeavors to increase the Engineering Foundation Fund and the Library Endowment. It has had some success, but as yet has obtained but a small part of the $7,000,000 sought.

The Committee on Development continued its study of ways to provide for future demand of the Societies for offices and other space, due to their growth.

The Committee on War Memorial to American Engineers, having completed its duties in connection with the carillon and the clock placed in Louvain Library, was discharged in September with commendations for the great success achieved. Contact with our memorial is now maintained through an international committee.

All departments closed the year without deficit. The income of the Administrative Department was $6,937.37 greater than predicted in the budget, due mostly to revenue from the halls, and the expenditures for all purposes was $5,391.57 less than the budget.

A summary of the Financial Report for the year follows.

SUMMARY

OPERATION OF BUILDING

Credit Balance January 1, 1929		$ 16,369.38
Building Revenue 1929	$132,326.21	
Building Expenditures 1929	116,422.18	15,904.03
Total		$ 32,273.41
Annual Payment to Dep. & Renewal Fund	12,436.25	
Reimbursement of General Reserve Fund	6,000.00	
Payment to Reserve for Future Fire Ins.	1,500.00	
Less Accounts charged off	46.50	19,982.75
Credit Balance December 31, 1929		$ 12,290.66

OPERATION OF LIBRARY

Maintenance Revenue	$ 47,986.24	
Maintenance Expenditures	44,963.86	
Credit Balance December 31, 1929	3,022.38	
Credit Balance January 1, 1929	425.55	
Total Credit Balance December 31, 1929		$ 3,447.93
Service Bureau Revenue	$ 20,154.30	
Service Bureau Expenditures & Adjustments	20,065.91	
Credit Balance December 31, 1929	88.39	
Credit Balance January 1, 1929	3,927.86	
Total Credit Balance December 31, 1929		$ 4,016.25

FUNDS AND PROPERTY

Funds held by E. F. Inc., Dec. 31, 1929 (book value)	
Depreciation and Renewal Fund	$ 257,247.14
General Reserve Fund	7,317.90
Engineering Foundation Fund	530,584.01
Henry R. Towne Engineering Fund	49,953.13
Library Endowment Fund	173,170.14
Edward Dean Adams Fund	99,241.71
John Fritz Medal (Custodian)	3,500.00
Louvain Memorial Fund (cash in bank)	8,561.94
Total	$1,129,575.97
Real Estate owned, cost to Dec. 31, 1929	1,973,410.42
Operating cash and petty cash	13,631.57
Accounts Receivable	1,838.73
Value of Library (as appraised for insurance)	336,579.00
Endowment Committee Loan Receivable	1,700.00
Unexpired Fire Insurance Premiums	4,818.82
Total Property which E. F. Inc. owns or holds	$3,461,554.51

The Development of Transportation in and About New York

On the evening of March 3, 1930 at 8 o'clock Billings Wilson, Deputy Manager of the Port Authority in charge of Port Development in New York, will give a talk on the "Development of Transportation In and About New York." The meeting will be held in the Engineering Auditorium, 33 West 39th Street, New York, N. Y. Following the meeting there will be an inspection of the Museum of the Peaceful Arts at 24 West 40th St. All members of the Institute are cordially invited to attend the meeting and inspection.

PERSONAL MENTION

HENRY D. JACKSON, Engineer, 698 Beacon Street, Newton, Centre wishes to notify his various friends with whom he has had many years of pleasant contact that he has retired from active business.

He thanks all for their many courtesies and wishes them continued prosperity. Mr. Jackson joined the Institute in 1903.

ROY PAGE, who since 1918 has been Assistant General Manager of the Nebraska Power Company, Omaha, Nebraska, has just been made its General Manager to succeed J. E. Davidson, who is now President and who was recently named Omaha's "most distinguished citizen" for 1929. Mr. Page is also President of the Nebraska Section of the N. E. L. A. and Chairman of the Engineering Section of its Midwest Division.

MR. FRANK J. BURD, A. I. E. E. Member, on February 1st became Manager of the Philadelphia Office for Cutler-Hammer, Inc., pioneer manufacturers of electrical control apparatus, with main office at Milwaukee, Wis. His knoweldge and electrical experience on the application of motors and their control is spread over practically every industry, and he has been much in demand as a speaker for engineering societies besides contributing numerous articles to the various publications on the subjects of Motor and Control.

John M. Morehead, Fellow of the Institute, was named United States Minister to Sweden by President Hoover on January 22. The appointment has been confirmed by the Senate and Mr. Morehead will present his credentials in Stockholm late this month.

Mr. Morehead has made important contributions to the acetylene, oxygen, and illuminating gas industry. At the time of his appointment he was associated with the Union Carbide and Carbon Corporation of New York.

P. H. Powers, Commercial Manager, West Penn Power Company, has been promoted to Vice-President in charge of all sales and commercial activities including operation of division and district offices. He has been with West Penn interests since 1922, starting as Division Manager of the Keystone Power Corporation at Bellefonte, Pennsylvania, becoming General Manager of that company in 1924 and Commercial Manager of West Penn Power Company at Pittsburgh in February, 1928 which is the office he held until his present appointment as Vice-President. He joined the Institute in 1921.

C. W. G. Little, who has been an Associate of the Institute since 1896 and since 1889 an earnest worker in the field of electrical industry has now retired from the position of Chief Engineer to the British Electrical Federation—not however, his many friends will be glad to learn, on account of ill health or inactivity.

Mr. Little installed the first three-phase e. h. t. transmission system with converter substation in Great Britain. His work has been identified with many pieces of electrical engineering work of exceptional interest and utility.

Donald McNicol, Fellow A. I. E. E. and Past-President of the I. R. E., has been appointed Editorial Director of the two publications *Radio Engineering* and *Projection Engineering*.

Since 1900 Mr. McNicol has been closely identified with radio and sound projection developments. He is the author of many technical papers on radio, including the more extensive work: "The Engineering Rise in Radio," widely read in all parts of the world. He is also the author of four standard text books on communication subjects.

For four years he was chairman of the Institute's Committee on Communication, and for eight years a member of its Publication Committee. He is internationally known in radio and communication circles.

Obituary

Fred M. Kimball, advisory manager of the motor division of the industrial department of the General Electric Company and an Associate of the Institute since 1903 died at Lynn, Massachusetts February 5, 1930. Mr. Kimball was well known throughout the motor industry and had seen many years of service with General Electric. He had been ill for some time.

Born in Barton, Vermont, July 7, 1861, he when a year old went to Somerville, Mass. with his parents. He received his education in the State of Massachusetts, including a course in Electrical Engineering at Massachusetts Institute of Technology. Early business associations was with the Merchants Electric Light Company of Boston, the American Electric Illuminating Company and the Electrical Development and Manufacturing Company. In 1886 he established a business partnership specializing in the manufacture and sale of isolated lighting plants, motors, and electrical specialties. In 1891 he entered the employ of the General Electric Company, New England District, and in 1898 at its formation was made Manager of the Small Motor Department. He was a member of the N. E. L. A., an Edison Pioneer, and an Honorary Member of the Providence Engineering Society.

Francis C. Pratt, who has been an Associate of the Institute since 1912, died at his home in Schenectady, New York, January 26, 1930. He was born in Hartford, Connecticut in 1867, attended the Yale University Sheffield Scientific School and from 1888 to 1906 was affiliated with the Pratt & Whitney Company, Hartford, Connecticut. Before leaving that company to take a position with the General Electric Company, he had been its vice-president and secretary. His record of service with the latter company was also worthy of note. He joined it in 1906 as an assistant to Mr. E. W. Rice, Jr., in charge of manufacturing and engineering. In 1913 he was made assistant to the President and in 1919 Vice-President. As such, he first had charge of engineering and later of both engineering and manufacture. He was a member of the munitions standards board of the United States Council of National Defense in 1917; a Trustee of the Sheffield Scientific School, Yale University, a Trustee and former head of the Hospital Association of Schenectady, a former Trustee of the Albany Medical College of Union University and former President and member of the executive committee of the Yale Engineering Association, serving many important committees of this body and acting as its representative on the alumni Advisory Board. He was also an honorary member of the Aurelian Honor Society of Sheffield Scientific School. Four years ago an honorary degree of M. A. was conferred upon him by Yale University. His memberships in clubs included the University and Yale Clubs of New York; the North Woods Club of Minerva, Essex County; Yourilli Club of Quebec and the Mohawk and Mohawk Golf Clubs of Schenectady. He was a member of the American Society of Mechanical Engineers and of the Schenectady Chamber of Commerce.

Harry L. Tanner, President of the Tanner Engineering Company and a member of the Institute for the past twenty years, was killed in an automobile accident in Brooklyn, February 11, 1930. He was born at Blodgett Mills, New York, September 5, 1883 and in 1904 was graduated from the State Normal School at Cortland. This education was supplemented by a course in Electrical Engineering at the University of Michigan, from which he was graduated in 1908. He immediately entered a student apprentice course in the Test Department of the General Electric Company and in 1909 entered the Transformer Department where his work consisted of transformer calculations. The following year he received an appointment as Instructor in Electrical Engineering at the University of Michigan, at the same time doing preliminary lay-out work for the Ontario Power Company of Niagara Falls, for contemplated extensions to the plant and a complete set of wiring diagrams for the existing plant. As Instructor at the University his work included electrical machine design, electrical engineering laboratory work, photometry, illumination, and general electrical engineering courses. Of the course in photometry and illumination he had entire charge for two summer sessions. From 1913 to 1915 he was engineer with the Sperry Gyroscope Company of Brooklyn, in entire charge of all testing. He also designed many pieces of apparatus for the company, much of this being of a special nature and requiring considerable original work. He was also responsible for several inventions patented and manufactured by the company, including an automatic d-c. booster-crusher voltage regulator, an electric system for transmitting signals, gyroscope devices and improvements for the hyroscope compass and airplane stabilizer, etc. Three of the company's engineers and a man in charge of the testing came directly under his supervision, and in every capacity in which he served, he proved himself an able executive.

John H. Finney, a member of the Institute since 1902 and for the past 25 years the southern representative for the Aluminum Company of America, died at Washington, January 29, 1930.

Born on October 10, 1865 in Amelia County, Virginia, Mr. Finney was educated in common and private schools in Virginia. In 1881 he accepted a position as telegrapher with the Rich-

mond and Allegheny Railroad Company. Two years later he engaged in mercantile business in Richmond, where he remained until 1887, when he entered the employ of the old Davis Carbon Company, later the Fidelity Company, of St. Louis, as electrician in the plating department. Here he had charge of the copper plating room (electric light carbons). From 1889 to 1890 he was with the Westinghouse Electric and Manufacturing Company, in the Cincinnati office, as salesman. From 1891 to 1896 he was engineering salesman with the Northwest General Electric Company at St. Paul, Minn. In 1896 he was appointed District Manager for the Fort Wayne Electric Corporation, with headquarters in Minneapolis. A year later he was transferred to the Rochester office in charge of sales for the western portion of New York State. In 1898 he became Manager of the Canandaigua Electric Light and Railway Company, leaving there in 1899 to accept the position of Engineer Salesman and District Manager for the Crocker-Wheeler Company at Washington. He gave up this position in 1900 to become Western Sales Manager for the Stanley Electric Manufacturing Company at Chicago. The following year he entered the employ of the Aluminum Company of America, as Manager of the company's southern territory. His work has been chiefly along engineering lines.

Mr. Finney became an Associate of the American Institute of Electrical Engineers on Sept. 26, 1902. He was transferred to the grade of Member May 20, 1913, and was elected a Manager May 19, 1914.

Mr. Finney had for many years taken an active part in the affairs of the Institute. Besides being a member of the Board of Directors, he was a member of the Executive Committee, Chairman of the Committee on Water Power Development, and one of the representatives of the Institute upon the Pan-American Engineering Joint Committee. He took a prominent part in matters relating to water power, and frequently represented the Institute at congressional and senatorial hearings on that subject. He also appeared and presented a statement at the Water Power Conference held in Portland, Oregon, September 21-23, 1915, upon the invitation of the Honorable James Withycombe, Governor of the State of Oregon.

A. I. E. E. Section Activities

NEW YORK SECTION MEETING POWER GROUP

The third meeting of the Power Group of the New York Section will be held on Tuesday evening, March 11, 1930 at 7.30 p. m. in the Auditorium of the Public Service Electric and Gas Co., at the Terminal Building, Newark, N. J.

The general subject of the meeting will be "132-Kv. Underground Transmission." Two papers will be presented, as follows: C. T. Hatcher of the United Electric Light and Power Co., will describe the two 132 kv. feeders from Hell Gate to Dunwoodie, covering the type of cable, methods of installation, splices, oil stops and operational data. G. T. Minasian of the New York Edison will talk on conduit and manhole design for transmission lines. The advantages and disadvantages of different designs will be covered. Talks will be illustrated and there will be plenty of time for discussion.

FUTURE SECTION MEETINGS

Akron

March 14, 1930. *Selection of a Motor as Determined by the Type of Load*, by G. E. Stolz, Manager Industrial Engineering Department, Westinghouse Elec. & Mfg. Company.

April 11, 1930. *System Planning*, by E. C. Stone, System Development Manager, Duquesne Light Company, and Vice-president District No. 2. Meeting to be held at Canton.

Cleveland

March 20, 1930. *Student Papers*, by Dr. W. E. Wickenden, President of Case School of Applied Science. Joint meeting with Case School of Applied Science Branch.

April 17, 1930. *Quality Characteristic of Electrical Hardware*, by F. L. Wolf, Technical Supt., The Ohio Brass Company. Inspection meeting at the Ohio Brass Company. Cafeteria dinner.

Detroit-Ann Arbor

March 18, 1930. *The Electrical Industry in America*, by Paul S. Clapp, Managing Director, N. E. L. A., New York, N. Y. Meeting to be held at the University of Michigan, Ann Arbor, Michigan.

April 22, 1930. *The Deion Circuit Breaker*, by Joseph Slepian, Consulting Research Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., and originator of this new breaker. Meeting to be held at the Detroit Edison Auditorium.

Madison

March 15, 1930. *Taking the Guess Out of System Protection*, by William C. Hahn, General Electric Company, Chicago, Ill.

Niagara Frontier

March 21, 1930. *By Products of Radio*, by Dr. Phillips Thomas, Research Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. Meeting at the Hotel Statler, Buffalo, N. Y.

April 18, 1930. *Use of Regulators in Industry*, by J. H. Ashbaugh, Regulator Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. Meeting to be held at Power House No. 2, Edward Dean Adams Plant.

Pittsburgh

March 8, 1930. Inspection trip. Homestead Steel Works of the Carnegie Steel Co., Homestead, Pa.

April 8, 1930. *Electrical Developments in Russia*, by Col. Hugh L. Cooper, President, Hugh L. Cooper & Co. Inc., New York, N. Y.

Seattle

March 18, 1930. Annual joint meeting of the local Sections of the four Founder Engineering Societies. Program of general interest to engineers, sponsored by the Western Washington Section of the American Society of Mechanical Engineers.

April 15, 1930. Joint meeting with the University of Washington Student Branch. Program under the direction of Professor George L. Hoard, University of Washington.

THIRD MEETING OF CHICAGO SECTION POWER GROUP

The third meeting of the Power Group of the Chicago Section was held February 12, 1930. Mr. L. R. Janes, of the Public Service Company of Northern Illinois presented a paper on *Load Division in Transmission Networks* before a group of about 100 engineers of Chicago and the vicinity. After a brief introduction consisting of a review of operating characteristics of high-voltage transmission lines, Mr. Janes outlined a simplified procedure which can be used to obtain the division of load in a complicated high-voltage network such as exists in the Chicago region. The paper was well illustrated by numerous slides and vector diagrams. Mr. Janes stated that the test results obtained on typical cases showed that the precision of results obtained by the simplified methods was ample for practical purposes.

The discussion which followed the presentation showed considerable interest on the part of the engineers in this timely subject.

PAPERS BY YOUNGER SECTION MEMBERS

The first of two joint meetings planned by the Pittsfield and Schenectady Sections, for the purpose of encouraging their younger members to participate in programs, was held in Schenectady on February 7, 1930; the other was held in Pittsfield on February 18.

The papers named below, chosen through competition and including three from each Section, were presented at the Schenectady meeting.

Generator-Voltage Regulator Compensation, by M. L. Waring, Central Station Engineering Dept., Schenectady.

The Non-Resonating Transformer, by W. A. McMorris, Pittsfield.

The Automatic Polarity Control of Electric Precipitators, by R. H. Kaufman, Industrial Engineering Dept., Schenectady.

The Capacitor Motor, by A. F. Lukens, Pittsfield.

Lightning Protection of Rotating Electrical Machinery, by E. W. Boehne, General Engineering Department, Schenectady.

Small Capacity High-Voltage Substations for Rural Service, by E. T. Parsons, Pittsfield.

First and second prizes were awarded as follows:

First—$15.00, E. T. Parsons, Pittsfield.

Second—$10.00, R. H. Kaufman, Schenectady.

The judges announced the total number of points as Schenectady 253.2 and Pittsfield 241.2.

The attendance was 180, and 35 members of the Pittsfield Section attended a dinner preceding the meeting.

Due to a thorough preliminary preparation by the authors, the character of their presentations was excellent, and interest shown by the speakers and audience was such that the officers enthusiastically suggested that other Sections hold such meetings.

JOINT MEETING OF LOCAL SECTIONS IN VIRGINIA

The Local Sections of the A. S. C. E., A. S. M. E., and A. I. E. E., and the Engineers Club of Hampton Roads, held a joint meeting at the Southland Hotel, Norfolk, Va., January 24-25, 1930. The general subject for discussion was "Virginia Industries," and the program is given below. The attendance was 125.

FRIDAY, JANUARY 24TH

9:00 a. m.	Registration
10:00 a. m.	Business sessions of State Sections.
10:30 a. m.	Moving picture. "For the Old Dominion."
11:00 a. m.	Victor Serbell, Chairman, Virginia State Section, A. S. M. E.—Presiding. Speaker, A. L. Griffin, Vice-President, F. S. Royster Guano Co. "Fertilizer Manufacture." Speaker, R. S. Huddleston, President, Huddleston Mahogany Co. "The Mahogany Industry."
1:00 p. m.	Luncheon. W. T. Howe, President, Engineers Club of Hampton Roads, Presiding. Major S. Heth Tyler, Mayor of Norfolk. Welcoming address. Speaker, Professor W. S. Rodman, Vice-president American Institute of Electrical Engineers.
3:00 p. m.	H. C. Leonard, Chairman, Society Virginia Section, A. I. E. E., presiding. Speaker, J. B. Woodward, Jr., Assistant General Manager, Newport News Shipbuilding and Dry Dock Company. "Shipbuilding." Speaker, J. L. Warner, Engineer, E. I. Dupont de Nemours & Co. "Dupont Industries in Virginia."
6:30 p. m.	Dinner. H. G. Shirley, Chairman, Virginia State Section, A. S. C. E., Presiding. Speaker, Dr. W. A. R. Goodwin, Rector of Bruton Parish Church. "Reconstruction of Williamsburg." Speaker, Lee Long, President, Virginia Coal Operators Association. "Coal Mining."

SATURDAY, JANUARY 25TH

Inspection of Newport News Shipyard.

At the business meeting of the Southern Virginia Section of the Institute, the present officers were reelected, as follows: H. C. Leonard, Chairman; Cecil Gray, Secretary-Treasurer; S. W. Anderson and J. E. Jackson, Executive Committee.

DEBATE HELD BY UTAH SECTION AND BRANCH

The feature of a joint meeting of the Utah Section and the University of Utah Branch, held in Salt Lake City, January 13, 1930, was a debate—"Resolved: That for a city having a population of 100,000, a multiple incandescent street lighting system is better than a series incandescent street lighting system."

A. N. Gyer and F. J. McCluskey of the Section spoke on the affirmative, while the negative was upheld by Frank Young and R. E. Griggs of the Branch. The decision was awarded to the negative by unanimous vote of the judges.

PAST SECTION MEETINGS

Akron

Railway Electrification, by J. V. B. Duer, Pennsylvania Railroad Co. Discussion followed. December 13. Attendance 125.

Public Transportation in Akron, by L. G. Tighe, Northern Ohio Power & Light Co. January 10. Attendance 24.

Baltimore

Superspeeded Speech, by J. B. Taylor, General Electric Co. Illustrated. January 24. Attendance 125.

Birmingham

Telephony Between Ship and Shore, by J. W. Relfe, Southern Bell Telephone and Telegraph Co.;

The Operation of Interconnected Power Systems, by W. W. Eberhardt, Alabama Power Co. January 27. Attendance 32.

Chicago

Major G. M. Barnes, Ordnance Dept., U. S. Army, spoke on the development of anti-aircraft artillery. Illustrated. Dinner in honor of Major Barnes preceded meeting. Joint meeting with the Western Society of Engineers. February 3. Attendance 300.

Cincinnati

Mechanical Transmission of Power, by Walter Geist, Allis Chalmers Mfg. Co. Illustrated. Dinner preceded meeting. January 9. Attendance 70.

Cleveland

Electricity and the Universe, by David Dietz, Scientist and Author. January 16. Attendance 178.

Columbus

X-Rays by J. L. Taylor, Victor X-Ray Corporation. Film, "The Wizardry of Wireless." January 17. Attendance 75.

Electrical Details of the Coal Handling Facilities at Toledo, Ohio, by R. E. Rice, New York Central Railroad. January 31. Attendance 13.

Connecticut

Television, by J. O. Perrine, American Telephone and Telegraph Co. Illustrated with slides. January 23. Attendance 150.

Denver

The Electrical System of the Public Service Co. of Colorado, by R. F. Throne and W. D. Hardaway, Public Service Co. of Colorado. Illustrated with lantern slides. Dinner preceded the meeting. January 17. Attendance 67.

Educational Activities of Large Manufacturing Companies, by C. S. Coler, Westinghouse Electric & Mfg. Co. Dinner preceded the meeting. January 30. Attendance 37.

Detroit-Ann Arbor

Motoring Through Europe, by Professor A. H. Lovell, University of Michigan. Illustrated with slides. January 21. Attendance 150.

Erie

The Quest of the Unknown, by Professor Harold B. Smith, President, A. I. E. E. Dinner preceded meeting. January 25. Attendance 70.

Houston

Lightning Protection, by G. N. Pingree, General Electric Co., illustrated with lantern slides. Meeting preceded by dinner. January 23. Attendance 25.

Ithaca

Automatic Train Control, by W. H. Reichard, General Railway Signal Co. Joint meeting with Cornell University Branch. Refreshments served. January 17. Attendance 130.

Kansas City

Visible Sound and Audible Light, by J. B. Taylor, General Electric Co. January 17. Attendance 190.

Modern Circuit Breaker Developments, by C. H. Sanford, Westinghouse Elec. & Mfg. Co. Buffet luncheon served. February 11. Attendance 72.

Los Angeles

Progress Made in Industrial Heating, by E. J. Cipperley, General Electric Co. H. H. Douglas, Southern California Edison Co., C. H. Dye, Bureau of Power & Light, and J. Max Lee, J. Max Lee Electrical Manufacturing Co., spoke on the subject of electric heating. Dinner preceded the meeting. January 14. Attendance 75.

Louisville

Wonders of Sound Transmission, by Sergius P. Grace, Assistant Vice-President, Bell Telephone Laboratories, Inc. Demonstrated. Joint meeting with the A. S. M. E., Engineers and Architects Club, and N. A. P. E. January 24. Attendance 1100.

Lynn

Local Convention Program: Talks on various phases of speed control, by D. F. Warner, H. E. Warren, R. G. Standerwick, B. W. St. Clair, D. M. Jones, and C. V. Reeves. General discussion and demonstrations. After adjournment, a party of about 25 visited the power plant of the River Works, General Electric Co., to inspect the latest methods of frequency control. January 15. Attendance 305.

Madison

Behavior of Dielectrics, by R. R. Benedict, University of Wisconsin. Film, "The Largest Hydro-Generating Station in the World." G. P. Steinmetz, State Water Power Engineer, gave some statistical data pertaining to the water power developments in the State of Wisconsin. January 15. Attendance 33.

Mexico

Dinner meeting. January 21. Attendance 24.

Minnesota

Some Developments in the General Electric Research Laboratory, by H. D. Sanborn, General Electric Co. January 29. Attendance 75.

Niagara Frontier

Reminiscences of Niagara's Industrial Development, by James G. Marshall, Union Carbide Co. Dinner preceded the meeting. December 13. Attendance 95.

Some Engineering Features of the Welland Ship Canal, by F. E. Sterns, Welland Ship Canal. The meeting was under the auspices of the Niagara Peninsula Branch Engineering Institute of Canada, Hamilton Branch E. I. of C., Engineering Society of Buffalo, and the Niagara Frontier Section, A. I. E. E.

Philadelphia

Refined Heating for Residences, by Chester I. Hall, Hall Electrical Heating Co. Illustrated with slides. January 13. Attendance 125.

Pittsfield

The State Line Power Station, by A. M. Rossman, Sargent & Lundy. January 21. Attendance 115.

A Trip Around the World in the Graf Zeppelin, by Lieut. Commander Charles Emery Rosendahl. Illustrated with motion pictures. February 4. Attendance 850.

Portland

Educational Activities of Large Manufacturing Companies, by C. S. Coler, Westinghouse Elec. & Mfg. Co. January 14. Attendance 48.

Providence

Power by Radio, by Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations followed. December 4. Attendance 105.

Conowingo Power Development, by A. A. Northrop, Stone & Webster, Inc. Illustrated with slides and motion pictures. Dinner preceded the meeting. January 14. Attendance 75.

Rochester

Superspeeded Speech, by J. B. Taylor, General Electric Co. Joint meeting with the Rochester Engineering Society. The meeting was preceded by a dinner in honor of the speaker December 10. Attendance 128.

St. Louis

Superspeeded Speech, by John B. Taylor, General Electric Co. January 15. Attendance 325.

Schenectady

Marine Applications of Electricity, by F. V. Smith, General Electric Co. January 17. Attendance 75.

High Strength Aluminum Alloys for Producing Light Structures, by R. L. Streeter, United States Aluminum Co. January 24. Attendance 75.

Seattle

Educational Activities of Large Manufacturing Companies, by C. S. Coler, Westinghouse Elec. & Mfg. Co. January 21. Attendance 72.

Sharon

Colombia, Panama, and Ecuador, by Stephen Q. Hayes, Westinghouse Elec. & Mfg. Co. Illustrated. Film, "Auto Proving Ground." January 7. Attendance 196.

Springfield

Modern Trends in Aircraft Radio Developments, by Lewis M. Hull, Aircraft Radio Corporation, Boonton, N. J. Illustrated with slides. January 13. Attendance 98.

Toledo

Lighter than Aircraft, by V. R. Jacobs, The Goodyear Tire & Rubber Co. Moving pictures describing the Zeppelin type of aircraft presented. Joint dinner meeting with the Toledo Foremans Club, Toledo Aviation Club, and the Affiliated Technical and Engineering Societies of Toledo. January 15. Attendance 500.

The Quest of the Unknown, by Professor Harold B. Smith, President, A. I. E. E., illustrated with lantern slides. January 24. Attendance 65.

Toronto

Mercury Arc Rectifier, by O. K. Marti, American Brown Boveri Co. Illustrated. January 10. Attendance 207.

Worcester

Lightning and Surge Voltage, by Alfred L. Atherton, Westinghouse Elec. & Mfg. Co. January 28. Attendance 30.

Inspection trip to the Worcester Gas Light Co., followed by a dinner at the American Steel & Wire Co. The manufacture of gas was described by A. C. Frye. Joint meeting with the A. S. M. E. and the Worcester Section of Chemical Engineers. February 7. Attendance 70.

A. I. E. E. Student Activities

BRANCH ORGANIZED AT PRATT INSTITUTE

At the meeting of the Board of Directors held December 3, 1929, the formation of a Student Branch at Pratt Institute, Brooklyn, N. Y., was authorized. This Branch was organized on February 5, 1930, and officers were elected as follows: Glen R. Glasscock, Chairman; R. B. Cramond, Vice-chairman; K. H. Stanger, Secretary; F. T. Crabb, Treasurer. A. L. Cook has been appointed Counselor.

PAST BRANCH MEETINGS

Alabama Polytechnic Institute

The Gorgas Steam Plant, by J. M. Johnson, Student;

The Automatic Reclosing Switch, by J. L. Stone, Student. Chairman R. F. Ham discussed plans for increasing the membership of the Branch. January 9. Attendance 9.

What Makes a Man's Career Successful, by Mr. Van Blarcom, Westinghouse Elec. & Mfg. Co.;

Summer's Work at Detroit, Michigan, by Eugene Walters, Student. January 30. Attendance 42.

The following talks were given by Students:

Small Electrical Contracts, by J. F. Turner;

Sectionalization of the Alabama Power Company's Transmission Lines, by R. P. Lapsley;

The Curb Engineer, by T. N. Pyke;

Bell Alarm System, by T. E. Curtis;

The Electrification of the Great Northern Railway, by J. M. Johnson. February 6. Attendance 59.

University of Arizona

Film, "Okonite Rubber Products." December 20. Attendance 13.

Changing Trend in Insulating Transformer Apparatus, by R. Goar, Student. January 10. Attendance 10.

Deion Circuit Breaker, by O. K. Mangum, Student. January 17. Attendance 11.

Beginnings of Alternating Current in America, by J. M. McBride, Student;

Elevator Equipment, by K. O. Kelton, Student. February 3. Attendance 12.

University of Arkansas

Professor C. L. Farrar spoke on his work in eliminating radio interference for the Idaho Power Co. October 23.

Film, "The Single Ridge." Debate on the subject, "Engineers Should Have More Electives in the College of Arts and Sciences." December 4.

Literature and the Engineer, by James Goss;

Opportunities for the Engineer in the U. S. Civil Service, by Guy Cunningham;

Voltage Regulation at the Fayetteville Plant of the Southwestern Gas and Electric Co., by J. C. Howard, Student.

G. W. Steltzlen spoke on his work with the Tesla coil he is building. Joint meeting with the A. S. M. E. Branch and A. S. C. E. Chapter. December 18.

Social Aspects of Public Utilities, by D. J. Morrison, Student;

Transportation, by Mr. Crawford, Student;

Power Developments, by B. E. Schnitzer, Student;

Future of High Pressure in Steam-Electric Plants, by Chester Robinson, Student. January 15. Attendance 16.

Photoelectricity, by Dr. Parsons, Physics Dept., accompanied by a demonstration of a photoelectric siren. February 5. Attendance 25.

California Institute of Technology

Recent Developments in the Theory of Conductivity, by William V. Houston. Meeting preceded by a luncheon. January 15. Attendance 19.

University of California

Description of the equipment for and methods used by the Pacific Gas & Elec. Co., and the Great Western Power Co. Load Despatching Offices, by Frank D. Lord, Student. Dr. Reukema, Counselor, spoke on the District and National prizes offered by the Institute. December 4. Attendance 33.

Catholic University of America

Hydroelectric Developments, by Professor T. J. MacKavanaugh, Counselor. Election of officers. October 11. Attendance 15.

The Automatic Burglar Alarm, by George A. Smith, Student. November 15. Attendance 15.

Engineering Achievements of 1929, by Everett C. McCleery, Student. December 15. Attendance 15.

Inspection Trip to the Conowingo Hydroelectric Development. November 19. Attendance 15.

University of Cincinnati

Problems Encountered in Designing the New Cincinnati Street Railway System, by J. Noertker, Cincinnati Street Railway Co. Moving pictures followed. January 22. Attendance 40.

Clarkson College of Technology

Problems in Naval Architecture, by John A. Ross, Head, Mechanical Engineering Dept., and Dean of Administration. January 21. Attendance 32.

Professor A. R. Powers, Counselor, outlined the advantages of Student enrolment and the plan whereby students may transfer to the Associate grade after graduation. February 4. Attendance 22.

Clemson Agricultural College

The following papers were given by Students:

Life of Pupin, by J. A. Graves;

Testing Large Turbines, by A. R. Kinard;

Growth of a Large Electrical Concern, by W. N. Foster;

Current Events, by T. T. Smoak;

Demonstration—Automatic Telephone Operation, by G. W. Sackman. January 9. Attendance 34.

The following papers presented by Students:

George Westinghouse, by M. T. Geddings;

Young College Men Snare Lightning, by G. B. Hagood;

World's Largest Convention Hall, by G. H. Epting;

Current Events, by G. C. Hoffman;

The General Electric Test, by G. A. Douglass. Illustrated. February 6. Attendance 34.

Colorado Agricultural College

Sound Picture Recording, by Kenneth Karst, Student. January 13. Attendance 12.

Synchronous and Induction Motors, by Paul Linden, Student. January 27. Attendance 16.

The University of Colorado

Mr. Shepard, U. S. Mint, spoke upon the development of new devices and the fields they opened up in research. Robert Temple, Robert Temple, Inc., demonstrated his high-velocity gun, called the Temple High-Velocity Driver. Joint meeting with the A. S. M. E., A. S. C. E., and Chemical Engineering Society. January 16. Attendance 160.

First Aid, by Dr. Carbon Gillaspie. January 29. Attendance 30.

A. L. Jones and M. M. Boring, both of the General Electric Co., spoke on the present opportunities of students as compared with several years ago. *Television and the Mechanical Eye,* by H. T. Plumb, General Electric Co. February 5. Attendance 260.

University of Denver

Film, "The World of Paper." January 17. Attendance 23.

The Achievements of the Westinghouse Electric & Mfg. Co. During the Past Year, by C. S. Coler, assisted by William Trudgian, both of the Westinghouse Elec. & Mfg. Co. January 31. Attendance 45.

Television and the Electric Eye, by H. T. Plumb, General Electric Co. February 4. Attendance 209.

University of Detroit

Elementary Principles of Light, by H. A. Kinley, Westinghouse Lamp Co. Illustrated. February 6. Attendance 85.

Drexel Institute

Discussion of plans for the Student Convention in March. January 10. Attendance 20.

Power Transformers, by Raymond Lapone, Student. Election of officers as follows: E. K. Cliver, Chairman; S. E. Harrison, Vice-Chairman; J. A. Kamershine, Treasurer; G. R. Bowers, Secretary. January 30. Attendance 26.

University of Florida

J. L. Sanders, Student, described his experiences while visiting a brick factory. M. H. Shahiman, Student, described his experiences in installing pipe organs. *The Ethics of the Engineer,* by Professor J. M. Weil, Counselor. February 10. Attendance 30.

Georgia School of Technology

The National Broadcast Network, by J. E. Smith, Student. Chairman L. B. Mann and J. R. Gilbert spoke on the convention held at VMI. December 10. Attendance 55.

W. F. Oliver, Southern Bell Telephone Co., gave an explanation of the operation of the telephone. Film, "Finding His Voice." January 7. Attendance 90.

University of Idaho

Discussion of Branch Activities. January 7. Attendance 22.

Banquet. *The Duties of an Electrical Engineer with the Operating Companies of the Bell System*, by Clarence E. Conway. Wayne McCoy, President, and J. H. Johnson, Counselor, spoke on their experiences while attending the 1929 Pacific Coast Convention. January 23. Attendance 28.

Discussion of plans for future Branch activities. February 5. Attendance 16.

Iowa State College

Northwestern Bell Telephone Co. gave a demonstration of Power-Arc Follow-Up. January 28. Attendance 75.

State University of Iowa

Film, "Current Generation." *Farm Lighting Plant*, by H. L. Lewis, Student. January 8. Attendance 36.

Problems of Public Utilities Administration, by F. W. Meyers, United Light and Power Co. January 15. Attendance 30.

Lafayette College

Underground Methods of Laying Telephone Cables, by R. Redfield, Student. January 11. Attendance 17.

Louisiana State University

Donald H. Bond, Student, reported on the power plant Stone & Webster are constructing in Baton Rouge. January 15. Attendance 22.

University of Louisville

High-Frequency Quartz Crystal Oscillators, by Edward Knoop, Student;

Ampere-Voltmeter Measurements, and *Kilovolt-Ampere Method*, by Charles Brody, Student;

Recording Torque Indicator, by Andrew Offutt, Student. January 25. Attendance 17.

Marquette University

Mr. Brown; T. M. E. R. & L. Co. gave a talk on a-c. networks. Constitution and By-laws read and discussed. January 16. Attendance 51.

Michigan College of Mining and Technology

O. Hane, Student, gave a summary of five student papers presented at the Chicago District meeting. Professor Young spoke of his trip to India and his experiences while there. January 30. Attendance 14.

University of Michigan

Long Distance Cable Telephone System, by A. B. Clark, Michigan Bell Telephone Co. Moving pictures and slides illustrated the talk. January 13. Attendance 100.

The Very Human Components of a Public Service Organization, by J. W. Parker, Detroit Edison Co. January 28. Attendance 100.

University of Minnesota

The Quest of the Unknown, by Professor Harold B. Smith, President, A. I. E. E. Joint meeting with Minnesota Section. November 27. Attendance 300.

The Application of the Photoelectric Cell to Communication, by J. O. Perrine, American Telephone and Telegraph Co. December 16. Attendance 300.

Missouri School of Mines

Talks by H. F. Kirkpatrick and C. J. Guin, Students, on the student courses offered at the Chicago Central Station Institute and the Union Electric Light and Power Co., St. Louis, Mo. January 31. Attendance 19.

University of Missouri

Generator Harmonics, by Professor A. C. Lanier. January 9. Attendance 21.

Montana State College

Henry Engle presented a lecture on the Cascade Tunnel accompanied by slides. Joint meeting with the A. S. C. E. Chapter.

Electric Locomotive Availability, by F. W. Bellinger, taken from the *General Electric Review*, presented by Roland Crumley, Student;

The Movies Come to Life, by Carl Dreher, taken from *Radio News*, presented by James Juidici, Student;

Electrical Operation for Elevators, by Charles R. Riter, taken from the *Electric Journal*, presented by Robert Erb, Student. January 16. Attendance 155.

L. H. Means, General Electric Co. gave an outline of the advantages graduates would find in the G. E. Test Course;

Joint Underground Service for Residential Area, by Clayton Briggs, taken from *Electrical West*, presented by Norman Hovey, Student;

Causes of Commutator Sparking, by Marin Phillips, taken from *Power*, presented by Paul Koetitz, Student;

An Outline of Step by Step Operation, by E. D. Butz, taken from the *Bell Laboratories Record*, presented by William McKay, Student. January 23. Attendance 155.

Konel—A Recently Discovered Alloy, taken from the *Electric Journal*, presented by Erwin F. Sauke, Student;

Acoustic Correction of Auditoriums, taken from the *Engineering News Record;*

Testing Lightning Arrester Grounds, by Edward Beck, taken from the *Electric Journal*, presented by Thomas Mica, Student. January 30. Attendance 155.

University of Nebraska

Safety for Engineers, by Mr. Kennedy, Iowa, Nebraska Light and Power Co. Demonstrated. Joint meeting with the A. S. M. E. Branch and A. S. C. E. Chapter. January 15. Attendance 80.

Radio-Telephone Program Service, by R. A. Richardson, Program Service Co. Talks by seven students. Election of officers as follows: V. L. Bollman, Chairman; L. D. Miles, Vice-Chairman; W. E. Stewart, Secretary-Treasurer. Dinner preceded the meeting. January 22. Attendance 40.

Mock Trial, "The Case of Widow Smith" presented. February 5. Attendance 150.

Newark College of Engineering

Television, by G. R. Ottinger, Bell Telephone Laboratories, Inc. Illustrated. January 20. Attendance 28.

Recording Meters, by Charles Goelzer, Student;

Electrical Plant Control, by William Schwerdefeger, Student. January 27. Attendance 30.

University of New Hampshire

Moving pictures illustrating the production of rubber. January 4. Attendance 46.

Dynamic Braking on Street Railways, by F. J. Robinson, Student;

Hydrogen Cooled Generators, by H. I. Coldwell, Student. January 11. Attendance 48.

Frequency Changers, by A. W. Boyles, Student. General discussion on the subject of dynamic braking. January 18. Attendance 46.

The following papers presented by Students;

Lightning Arresters, by H. Smith;

Mercury Vapor Rectifiers, by C. Evans;

The Ward-Leonard System of Elevator Control, by G. D. Ingham;

The Ilgner System of Control, by H. J. Cunningham. January 25. Attendance 43.

Arc Welding, by M. Bowker, Student;

Shaft Currents, by J. Carlen, Student. February 1. Attendance 44.

A Scientific Ghost Laid, by A. G. Pinkham, Student;

Army Searchlights and Remote Control, by D. M. Googins, Student. February 8. Attendance 43.

University of New Mexico

The Speed of Electricity, by Professor F. M. Denton, Branch Counselor. January 28. Attendance 10.

College of the City of New York

Election of Officers as follows: Eugene J. Erdos, Chairman; F. Wodicka, Secretary; N. Stadtfeld, Treasurer. January 14. Attendance 24.

Inspection trip to the Hell Gate Generating Plant. February 4. Attendance 17.

New York University

The Construction, Operation, and Maintenance of Switches for High-Tension Work, by Eric Salo, Student;

Ira Weisbaum, Student, reviewed the autobiography of the late Benjamin G. Lamme of the Westinghouse Elec. & Mfg. Co. January 10. Attendance 18.

North Carolina State College

Advancement of Engineering Education, by C. H. Belvin, Student;

Recent Development in Talking Pictures, by D. P. Melton, Student. January 21. Attendance 45.

University of North Carolina

The Manufacture of Lead Covered Cables, by C. D. Hart and Mr. Wells, both of the Western Electric Co. Illustrated.

North Dakota State College

The Development of the Ultra Violet Ray Sun Lamp, by J. C. Langaunet, Student;

The Life of C. F. Scott of the Westinghouse Elec. & Mfg. Co., by Jack Simonitch. Joint meeting with the Engineers Club. February 7. Attendance 54.

University of North Dakota

Automatic Substations, by Charles Libby, Student, illustrated with slides.

Professor Harold F. Rice, spoke about the National and District prizes offered by the A. I. E. E. January 15. Attendance 10.

Northeastern University

The History and the Development of the Incandescent Lamp, by H. C. Doyle, General Electric Co. Refreshments served. January 14. Attendance 50.

Notre Dame University

Interference from Electrostatic Sources, by Paul Rist, Student;

Radio in Aviation, by Patrick Murry, Student;

My Conception of an Electrical Engineer, by Mr. Milliam, Student;

Relativity, by Professor Daniel Hull. January 13. Attendance 78.

Metallurgy, by Mr. Hamill, Student, illustrated;

Automobile Generators, by F. Loney, Student;

Opportunities in the General Electric Co. for Graduate Engineers, by C. C. Adams, General Elec. Co. February 3. Attendance 50.

Ohio Northern University

The Construction, Defects and Manners of Testing Power Cables, by Mr. Mertz, Student;

Value and Uses of Audion Tubes, by Mr. Mustard, Student. January 9. Attendance 22.

Ohio State University

Dinner meeting at which Mr. Alexander, the weatherman for the City of Columbus explained how he determines the forecasts that are published daily. January 24. Attendance 38.

Oklahoma A. & M. College

Transient Voltages on Transmission Lines, by Wilbur Slemmer, Student;

The Ideal Lightning Arrester, by Paul Matheson, Student. February 6. Attendance 15.

University of Oklahoma

Discussion of plans for the electrical show to be held in March. February 4. Attendance 20.

Oregon State College

Talks by Chairman Ben Griffith and Professor F. O. McMillan, Counselor, on the advantages of Student enrolment in the Institute. A film was shown describing the manufacture of insulated copper conductors. Refreshments served. January 9. Attendance 32.

Pennsylvania State College

Three students spoke on their past experiences in the electrical field. January 14. Attendance 14.

My Automobile Camping Trip to the West and Back, by Ernest Axman, Student. January 21. Attendance 30.

University of Pennsylvania

Discussions of plans for Electric and Radio show. October 31. Attendance 29.

Meeting called for the purpose of acquainting the students with the apparatus to be used at the Electrical Show. November 7. Attendance 31.

Discussion of plans for increasing the membership of the Branch. December 19. Attendance 22.

Discussion of plans for banquet to be held in February and also the Student Branch convention to be held at Lehigh on March 14. January 16. Attendance 25.

University of Pittsburgh

Network System in Pittsburgh, by C. T. Sinclair, Duquesne Light Co. January 9. Attendance 71.

A Short Résumé of the Student Conference held on January 17, by J. K. Ely, Student;

Rubber, by F. R. Reed, Student. January 23. Attendance 68.

Pratt Institute

Illustrated lecture by A. F. Corby, Jr., Weston Electrical Instrument Corp., showing the construction details of the meters manufactured by this company. February 13. Attendance 150.

University of South Carolina

Inspection trip through the Southern Bell Telephone Exchange of Columbia. January 3. Attendance 35.

The Engineering Graduate of the Past Compared and Contrasted with Those of Today, by Dean W. E. Rose. January 8. Attendance 22.

Television, by L. E. Rankine, Student;

Recent Economic Developments, by C. H. Bryan, Student;

Armature Reactions, by C. H. Frick, Student. January 17. Attendance 23.

Business meeting. February 6. Attendance 19.

South Dakota State School of Mines

Two films, "Arc Welding" and "Electrical Measuring Instruments." February 6. Attendance 26.

University of South Dakota

The Spectrohelioscope and Its Place in Solar Research, by E. Lovejoy, Student. January 6. Attendance 8.

The Elementary Principles of Radio Communication, by Herbert Scholes, Student. January 20. Attendance 7.

Film, "Through Oil Fields of Europe and Africa." January 21.

University of Southern California

Business meeting. January 8. Attendance 23.

Nomination of officers. January 15. Attendance 26.

Election of officers as follows: George Robertson, Chairman; Clair Black, Vice-chairman; Louis H. Hendrixson, Secretary; Stewart Scott, Treasurer. January 22. Attendance 27.

Southern Methodist University

Home Made Rectifiers for the Radio, by Henry Gable, Student;

Highway Crossing Signals, by Ben J. Beaird, Student. Election of officers as follows: Ben J. Beaird, Chairman; D. J. Tucker, Secretary. January 7. Attendance 16.

Swarthmore College

An Analytic Consideration of Induction Generator Phenomena, by George B. Hoadley, Student;

An Analysis of Centrifugal Pumps and their Relations to Water Systems, by Stanley I. Winde;

An Investigation of the Characteristics of Vacuum Tubes, by David C. Haskell, Student. January 17. Attendance 19.

Texas Technological College

Election of officers as follows: William E. Street, Chairman; Charles E. Houston, Vice-Chairman; Wilbur L. Pearson, Secretary-Treasurer; Dean William J. Miller nominated for Counselor. January 8. Attendance 23.

Executive Committee meeting. Committee appointments announced. January 13. Attendance 7.

Adoption of By-laws. January 15. Attendance 21.

University of Utah

Debate with Utah Section. See complete report in Section Activities Department of this issue. January 13. Attendance 50.

Banquet in honor of H. L. Means, General Electric Co. January 20. Attendance 24.

Luncheon in honor of C. S. Coler, Manager, Educational Dept., Westinghouse Electric & Mfg. Co. January 24. Attendance 23.

D. A. Lyon, U. S. Bureau of Mines, delivered a lecture on some of his own experiences in metallurgy. February 4. Attendance 18.

University of Vermont

Engineering Achievements of the Year 1929, by A. E. Merrill and L. M. Donahue, Students. February 10. Attendance 14.

Soldering Metal and Porcelain, taken from the *Electric Journal*, presented by J. Willis, Student;

Electronic Rectifiers, by Professor R. O. Buchanan. Illustrated. January 14. Attendance 15.

Virginia Polytechnic Institute

Electricity in Industry, by W. J. Pritchard, Student;

Life of Charles P. Steinmetz, by G. E. Brugh, Student;

On G. E. Test, by C. V. West, Student. January 31. Attendance 21.

University of Washington

Mr. DeSellum, Westinghouse Elec. & Mfg. Co. gave a talk on transformers, illustrated with lantern slides. January 10. Attendance 24.

Worcester Polytechnic Institute

William Locke, Jr., Student, spoke on his experiences while employed with the New York Telephone Co.;

Edwin Harper, Student, spoke on his experiences while employed by the Westinghouse Elec. & Mfg. Co. Refreshments served. January 20. Attendance 20.

University of Wyoming

Election of officers as follows: Roy A. Buckmaster, Chairman; Warren Hicks, Vice-Chairman; Jack E. Surline, Secretary-Treasurer. November 20. Attendance 13.

L. Probst, gave an address on practical problems in the telephone industry. January 21. Attendance 12.

Yale University

Five-reel film showing the preparation and use of dynamite. Joint meeting with the A. S. M. E. Branch. January 7. Attendance 54.

Railway Blocks and Signals, by Donald Crawford, Student;

Patents and the Patent Situation, by S. K. Oliver, Student. January 14. Attendance 16.

W. S. Murray, Murray and Flood, gave a detailed description of the planning and engineering of the Saluda Dam, near Columbia, So. Carolina. Illustrated with slides and motion pictures. February 10. Attendance 100.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York.

All members are urged to notify Institute headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and assuring the prompt delivery of Institute mail, through the accuracy of our mailing records and the elimination of unnecessary expense for postage and clerical work.

Asavaid, E. H., 146 B. Princess St., Bombay, India.
Bakker, J. B., 440 Hyde St., San Francisco, Calif.
Ball, Marshall T., 1017 Race St., Phila., Pa.
Birdsall, W. T., 6 Vincent Place, Montclair, N. J.
Brown, Garry E., 1280 Dean St., Brooklyn, N. Y.
Chin, Lung C., 200 Claremont Ave., Apr. 57, New York, N. Y.
Chitty, Wm. C., 2514 El Paseo, Granada Park, Alhambra, Cal.
Collinot, Marcel A., F. W. V. Rm. 1050, 11 W. 42nd St., New York.
DeCamp, H. H., 414 Ella St., Wilkinsburgh, Pa.
Degener, F. S., 1015 Casgrain Ave., Detroit, Mich.
De Salis, H. W., Box 66, Fort Frances, Ont., Can.
Duncan, W. C., 1121 Bedford Ave., Brooklyn, N. Y.
Eaton, T. O., 6523 Reedland St., Phila., Pa.
Fick, Ernest, A. T. &. T. Co., 412 S. Market St., Chicago, Ill.
Fortin, R. P., Elec. & Gas Inspection Ser., 125 Prince William St., St. John, N. B., Can.
Gates, R. H., Century Elec. Co., 1806 Pine St., St. Louis, Mo.
Gatternigg, R., Minarets, Calif.
Gioga, Peter, Metropolitan Sound Studios, 1040 N. Las Palmas, Hollywood, Calif.
Goldsborough, James, 50 Church St., Rm. 1272, New York.
Gorrissen, Chas., Hermannstrasse 38, Hamburg, Germany.
Grenfell, Richard R., 442 6th St., Brooklyn, N. Y.
Hamrick, G. R., Sweetwater, Tex.
Hardey, John E., Nat'l. Electrical & Engg. Co., Ltd., Box 1055, Wellington, N. Z.
Hedeby, H. V., P. O. Box 414, Sharon, Pa.
Hershey, H. E., Midwest Athletic Club, Madison St. & Hamlin Ave., Chicago, Ill.
Hyatt, C. Brown, Camac and Medary Sts., Philadelphia, Pa.
Irvine, H. B., 1 Union St., Schenectady, N. Y.
James, Edgar A., 912 S. Poplar St., Allentown, Pa.
Jeong, J. Y., 49 Mott St., New York, N. Y.
Keegan, W. G., 767 Maple Ave., Los Angeles, Calif.
Kirkland, E. H., 6701 Cregier Ave., Chicago, Ill.
Klien, F. A., 1215 Locust St., Philadelphia, Pa.
Matthews, R. F., 123 Livingston St., Brooklyn, N. Y.
McDougall, D. J., 1501 W. Pierce St., Phoenix, Ariz.
Nims, F. D., 70 State St., Boston, Mass.
Noome, C., Catharijnesingel 33, Utrecht, Holland.
Patrick, R. A., 425 Granite St., Reno, Nev.
Peck, W. G., R. C. A. Photophone, Inc., Ser. Eng. Dept., 411 5th Ave., New York, N. Y.
Quaas, Richard T., 545 W. 156 St., New York, N. Y.
Richman, S. L., 6823 McPherson Blvd., E. Pittsburgh, Pa.
Rivers, H. D., 298 Central Ave., Lynbrook, L. I., N. Y.
Sachse, A. O., 87 Court St., Newark, N. J.
Saliba, G. J., 311 86th St., Brooklyn, N. Y.
Schnug, Geo. J., 9 Garrison Ave., Jersey City, N. J.
Schwartz, Carl, Int'l. Combustion Engg. Corp., 200 Madison Ave., New York, N. Y.
Singer, R. H., 2214 Auburn Ave., Cincinnati, Ohio.
Slaboski, H. T., 1441 Main St., Northampton, Pa.
Smedberg, O. L., 916 12th St., Oregon City, Ore.
Stone, Walter, 4501 Malden St., Chicago, Ill.
Svensson, Gerhard, c/o Amer. Express Co., 65 Broadway, New York, N. Y.
Syed, Mustafa, 960 S. 9th St., Noblesville, Ind.
Tsatsaron, Nicholas, Central Restaurant, 300 W. 40th St., New York, N. Y.
Velasco, L. R., Apartado 8, Canargo, Cheh, Mex.
Vogeli, R., Byllesby Eng. & Mngt. Corp., Pittsburgh, Pa.
Wallis, C. W., 365 Willow St., Waterbury, Conn.
Watts, W. E. G., General Delivery, San Francisco, Calif.
Wheeler, R. E., 345 W. 58th St., New York, N. Y.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these founder societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August, when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, JANUARY 1-31, 1930

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

AGENDA DUNOD, 1930.

Automobile, by G. Lienhard.

Chemins de Fer, by P. Place.

Construction Mécanique, by J. Izart.

Electricité, by L. D. Fourcault.

Métallurgie, by A. Roux.

Physique Industrielle, by J. Izart.

Paris, Dunod, 1930. 6 v., illus., tables, 6 x 4 in., bound, 20,50 fr. each.

These pocket-books, which are revised each year, are prepared with the ordinary requirements of designers, builders, and operators in mind. Each volume contains the mathematical formulas, physical and chemical constants, and general data frequently needed. The size is an actual pocket size. The amount of information supplied is remarkable, in view of the surprisingly low price of the volumes.

ANALYSE DES MÉTAUX PAR ELECTROLYSE.

By A. Hollard and L. Bertiaux. 4th edition. Paris, Dunod, 1930. 232 pp., diagrs., 10 x 7 in., paper. 62,50 fr.

In addition to giving detailed descriptions of methods and apparatus for analyzing metals, alloys and commercial products, this manual sets forth the general principles, studies, and general methods of electrolytic separation and deposition of metals and discusses electric generators, etc. Although primarily devoted to electrolytic methods, other methods of analysis are described in cases where they are better.

APPAREILLAGE ELECTRIQUE HAUTE TENSION.

By Charles Bresson. Paris, Dunod, 1930. 460 pp., illus., diagrs., tables, 10 x 7 in., paper. 115,50 fr.

Treats of circuit-breakers and protective apparatus for high-tension lines. Such problems as insulation, heating, and short-circuit phenomena are discussed both theoretically and in relation to the construction of apparatus. The types of apparatus used are described.

DIE ASYNCHRONEN WECHSELFELDMOTOREN.

By Gustav Benischke. 2d edition. Berlin, Julius Springer, 1929. 123 pp., diagrs., 10 x 7 in., paper. 11,40 r. m.

After an introductory discussion of general principles, chapters are devoted to series-wound, shunt-wound, repulsion and commutatorless alternating-flux induction motors. Torque, power, sparking, electric braking are considered.

ATLAS METALLOGRAPHICUS, Lief. 6 & 7, Tafel 41-56.

By Hanemann and Schrader. Berlin, Gebrüder Borntraeger, 1929. Plates, 11 x 8 in., paper portf. 7.-r. m. each.

These two new sections of this atlas contain 128 photomicrographs showing the effect of various heat treatments on the structure of iron and steel. Full information concerning the composition, heat treatment, and etching is given in each case. The specimens are beautifully reproduced.

YEARBOOK ON COAL MINE MECHANIZATION. 1929.

By American Mining Congress. Edited by G. B. Southward. Washington, D. C., American Mining Congress, 1929. 390 pp., illus., 9 x 6 in., fabrikoid. $3.00.

Contains papers and reports by mine operators on various phases of mechanical mining and loading equipment. The present status of mechanization, power, ventilation, pillar recovery, safety and the effect of mechanized loading on mining methods are discussed. Reports are included on the status of mechanization here and abroad, on actual mining operations with loading and mining equipment, and on the types of equipment in use. A bibliography for the years 1920-29 is given.

BALANCING OF ENGINES.

By W. E. Dalby. 4th edition. N. Y., Longmans, Green & Co., 1929. 321 pp., illus., diagrs., tables, 9 x 6 in., cloth. $8.40.

A presentation of Professor Dalby's well-known method of solving balancing problems and finding balancing weights. Changes in the new edition include new chapters on the vibration of railway bridges and on the balancing of internal-combustion engines; a rewriting and extension of the chapter on locomotive balancing, as well as minor improvements and additions.

BRIDGES; a Study in their Art, Science, and Evolution.

By Charles S. Whitney. N. Y., William Edwin Rudge, 1929. 363 pp., illus., plates, 12 x 9 in., cloth. $20.00. (Edition limited to 2000 copies).

This beautiful volume will meet a number of needs. It discusses the application of fundamental architectural principles to bridge design and criticism, and pleads for the training of civil engineers in these principles. It reviews the development of bridge building from the earliest time to the present. It offers, in its four hundred plates, a remarkable pictorial review of artistic bridges of all ages and materials. The book will delight every bridge engineer.

THE CALCULUS.

By Hans H. Dalaker and Henry E. Hartig. N. Y., McGraw-Hill Book Co., 1930. 254 pp., 9 x 6 in., cloth. $2.25.

A beginning course in calculus which develops the principles and methods hand in hand with their application to carefully selected problems.

COMPTAGE DE L'ENERGIE ELECTRIQUE EN COURANTS ALTERNATIFS.

By J. Tartinville. Paris, Dunod, 1930. 154 pp., diagrs., tables, 10 x 7 in., paper. 39.-fr.

The author treats of the imperfections of meters, the factors that influence their exactness, methods of calibrating and regulating, maintenance, etc. Special attention is given to accuracy under light loads. The book aims to facilitate the choice of proper meters for given conditions.

DAMPFTURBINENSCHAUFELN.

By Hans Krüger. Berlin, Julius Springer, 1930. 132 pp., illus., diagrs., tables, 10 x 7 in., paper. 15.-r. m.

A treatise on steam-turbine blades, based on long experience in their manufacture. After a brief discussion of profiles, the author takes up the requirements of blade materials, the selection of materials, the properties of the metals and alloys used,

methods of working, damages during operation, and methods of testing and inspecting.

DESIGN OF ELECTRICAL APPARATUS.

By John H. Kuhlmann. N. Y., John Wiley & Sons, 1930. 455 pp., illus., diagrs., tables, 9 x 6 in., cloth. $6.00.

This text-book aims to give a clear, simple presentation of a practical method of design, with explanations of theory, procedure, and limits of design. The methods and presentation are based on experience as teacher and designer. D-c. machines, synchronous machines, induction motors, and transformers are successively treated; the construction of the apparatus, and the formulas and procedure outlined in each case, and illustrated by complete sample calculations.

DIATOMACEOUS EARTH.

By Robert Calvert. N. Y., Chemical Catalog Co., 1930. (American Chemical Society. Monograph series.) 251 pp., illus., diagrs., 9 x 6 in., cloth. $5.00.

Offered, according to the author, as "a description of the present day industry of diatomaceous earth, an interpretation of the literature in the light of experience, and an indication of needed discoveries." It affords a useful survey of the industry, covering occurrences of the earth, methods of mining and preparing, physical properties, and its uses as a filtering medium, a heat insulator, an absorbent, and for various minor purposes.

DIELECTRIC PHENOMENA IN HIGH-VOLTAGE ENGINEERING.

By F. W. Peek, Jr. 3d edition. N. Y., McGraw-Hill Book Co., 1929. 410 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

The purpose of this well-known book, to present the properties of gaseous, liquid, and solid insulations, and to show by what methods these properties can best be utilized in high-voltage engineering, remains as in previous editions. This edition, however, has been thoroughly revised in the light of the data that have been acquired through laboratory and field experience. New material includes the results of recent study of corona, of the impulse breakdown of gases, of the breakdown of insulation, and of sparkover voltages at very high voltage. A chapter on lightning has also been added.

DYNAMISCHE UND STATISCHE ZUGVERSUCHE AN ALUMINUM-EINZELKRISTALLEN.

By J. Weerts. (Forschungsarbeiten....heft 323). Berlin, V. D. I. Verlag, 1929. 20 pp., illus., diagrs., 12 x 8 in., paper. 4.-r. m.

An investigation of the reasons for the observed effect of speed of deformation of ductile metals upon their resistance to deformation. For this purpose, the author investigated the behavior of large aluminum crystals when subjected to various tests of their tensile strength. New light was obtained upon the phenomena of crystal deformation and resistance.

EFFECTS OF MOISTURE ON CHEMICAL AND PHYSICAL CHANGES.

By J. W. Smith. N. Y., Longmans, Green & Co., 1929. (Text-books of physical chemistry). 235 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

It has long been known that small quantities of water exercise a most important catalytic effect on the velocity of many chemical reactions, and in recent years attention has been called to remarkable phenomena that appear when solids and liquids are dried very intensively. Minute traces of moisture, it has been found, enormously influence the physical properties.

The available data upon the effects of removing water vapor from chemical systems are collected in the present work and correlated as far as is possible at present. Students of physics and physical chemistry will find it a useful summary of a curious and puzzling group of phenomena.

ELECTRIC SYSTEM HANDBOOK.

By Clarence Herbert Sanderson, editor-in-chief. N. Y., McGraw-Gill Book Co., 1930. 1167 pp., illus., diagrs., tables, 7 x 4 in., fabrikoid. $5.00.

An analysis and description of modern systems for generating, transmitting and distributing electric power, intended for students and operators. Higher mathematics is avoided. The generating stations, the transmission system, substations for various purposes, distribution, protection, inspection, maintenance, auxiliary equipment, switchboards, and motors are discussed from a practical point of view.

ELECTRICITY SUPPLY TRANSFORMER SYSTEMS AND THEIR OPERATION.

By William T. Taylor. Lond., Charles Griffin & Co., 1929. 243 pp., illus., diagrs., tables, 9 x 6 in., cloth. 20 s. (Gift of Author.)

This book is not concerned with transformer design or construction, but with the practical questions that arise after the transformer has left the factory. The author discusses the relative advantages of grounding *versus* insulating the neutral point, of polyphase *versus* single-phase units, of delta and star connections, of core and shell type units, of multiple grounding versus grounding at the supply end only, and a number of other questions which arise before the operating engineer. Attention is centered upon three-phase and single-phase systems, except for one chapter upon phase transformation involving the two-phase system.

ELEKTRO-WERKZEUGE KLEINWERKZEUGMASCHINEN MIT EINBAUMOTOR UND BIEGSAME WELLEN.

By Hans Fein. Berlin, Julius Springer. 1929. 112 pp., illus., 9 x 6 in., paper. 6,90 r. m.

Describes a wide variety of portable and bench drills, saws, planers, hammers, and other tools. The construction and uses are explained, data are given as to capacity, and suggestions made as to choice for any purpose.

ELEKTROBETRIEB IN DER TEXTILINDUSTRIE.

By Wilhelm Stiel. Leipzig, S. Hirzel, 1930. (Elektrizität in industriellen Betrieben, bd. 8). 652 pp., illus., diagrs., tables, 10 x 7 in., paper. 33.-r. m.

A comprehensive survey of the advantages of motor drives for textile machinery. The various processes of spinning and weaving are taken up one by one, and the selection and application of motor discussed. The book is not only a textbook on a branch of electrical engineering, but also a useful treatise on textile machinery and processes.

ELEMENTS OF ENGINEERING THERMODYNAMICS.

By James A. Moyer, James P. Calderwood, and Andrey A. Potter. 4th edition. N. Y., John Wiley & Sons, 1929. 195 pp., diagrs., 9 x 6 in., cloth. $2.50.

Aims to bring out the principles of the subject and the practical applications of those principles to steam turbines, internal combustion engines, refrigeration, and similar subjects. The new edition has been revised and in part rewritten.

ENTWURF UND BAU VON SCHALTANLAGEN FÜR DREHSTROM-KRAFTWERKE.

By Johann Waltjen. Berlin, Julius Springer, 1929. 268 pp., illus., diagrs., tables, 11 x 8 in., bound. 39.-r. m.

A text and reference book intended for students and designers. The layout of connections, instruments, and apparatus, and the design and construction of switchgear are treated from a practical point of view, with numerous practical examples.

DER ERDSCHLUSS UND SEINE BEKÄMPFUNG.

By G. Oberdorfer. Wien, Julius Springer, 1930. 165 pp., illus., diagrs., 9 x 6 in., paper. 12,50 r. m.

Discusses grounds in high-tension circuits and their prevention, from the point of view of the practical engineer. Attention is given to the mathematical treatment of grounding problems and to theory and practise in discovering, preventing, and removing them. A list of important German patents is included.

GASEOUS COMBUSTION AT HIGH PRESSURES.

By William A. Bone, Dudley M. Newitt, and Donald T. A. Townend. Lond. & N. Y., Longmans, Green & Co., 1929. 396 pp., illus., diagrs., tables, 10 x 7 in., cloth. $15.00.

This book is to be regarded, the authors state, as completing the review of the principal researches on flame and combustion from the time of Robert Boyle to the present which was begun with their "Flame and Combustion in Gases," published two years ago. It is chiefly concerned with the researches that have been carried out during the past 20 years by Dr. Bone and his collaborators. That work comprised the study of hydrogen-air, carbonic oxide-air, and methane-air explosions at initial pressures between 3 and 175 atmospheres, with the development of suitable apparatus for the investigation. An extensive bibliography and a convenient summary of the principal data relating to compressibilities of gases are appended.

GEOCHEMISCHE MIGRATION DER ELEMENTE.

By A. Fersmann. (Abhandlungen zur praktischen Geologie und Bergwirtschaftslehre, bd. 18). Halle (Saale), Wilhelm Knapp, 1929. 116 pp., illus., maps, tables, 9 x 6 in., paper. 10,20 r. m.

Dr. Fersmann aims to present the fundamental principle of geochemistry, the migration of chemical elements, by a discussion of concrete cases. For this purpose he has selected four mineral regions in Russia and Asia which have been recently explored by the Leningrad Academy of Science.

The present volume contains a general discussion of the problems of topo-mineralogical investigation, and an account of geochemical migration of elements under magmatic and pegmatic-pneumatolytic conditions as illustrated on the Kola peninsula and in the Ural emerald mines.

Geschlichtliche Einzeldarstellungen Aus der Elektrotechnik, edited by Elektrotechnischen Verein E. V., bd. 2; Die geschichtliche Entwicklung der Hochspannungs-Schalttechnik.

By Max Vogelsang. Berlin, Julius Springer, 1929. 176 pp., illus., diagrs., 9 x 6 in., paper. 21,-r. m.

This work traces the evolution of high-tension switchgear from its first use in 1886 down to the year 1914. The author has brought together a great amount of information not easily found elsewhere, and arranged it systematically. Many illustrations and drawings add to the value of the book.

Heat Loss Analysis.

By E. A. Uehling. N. Y., McGraw-Hill Book Co., 1929. 241 pp., diagrs., tables, 8 x 5 in., cloth. $2.50.

The heating value of the amount of coal that contains a pound of carbon is the same, within practical limits, for all coals of the same type. Taking advantage of this property, the author has developed simple formulas for calculating and analyzing the heat losses in a boiler plant. This book, which is intended for the boiler operating staff, explains in simple language the processes of combustion and heat absorption, shows how the recorded data can be resolved into the corresponding heat losses, and describes methods for applying the results to control operations.

High-Voltage Cables.

By P. Dunsheath. N. Y., Isaac Pitman & Sons, 1929. 161 pp., illus., diagrs., 9 x 6 in., cloth. $3.00.

This volume, based on a course of lectures delivered at University College, London, aims to present a concise general statement of the present state of cable design and operation, with some indications of probable lines of development. It discusses successively primary dielectric properties, dielectric loss and power factor, stress and breakdown, the physical properties of impregnated-paper cables, multi-core and single-core cables, current rating and stability, joints and terminals, and special cables and systems. The author is Research and Technical Manager to the W. T. Henley's Telegraph Works Company.

Introductory Mechanical Drawing.

By Clarence E. Townsend and Stephen F. Cleary. N. Y., John Wiley & Sons, 1930. 302 pp., illus., diagrs., 9 x 6 in., cloth. $3.00.

A carefully planned course, intended to give the basic theory and to train the student in practical work. The book is based on the course given in the College of Engineering, Cornell University.

Kompensierte und Synchronisierte Asynchronmotoren.

By H. F. Schait. Berlin, Julius Springer, 1929. 104 pp., illus., diagrs., 10 x 7 in., paper. 10, 50 r. m.

A text on the theory and design of these motors.

Die Korrosion, Bd. 1; Allgemeiner und theoretischer Teil.

By O. Kröhnke and W. Beck. Lpz., S. Hirzel, 1929. 208 pp., illus., tables, 9 x 6 in., paper. 16.-r. m.

The first volume of an elaborate monograph on corrosion and protection corrosion, which will give special attention to the extensive German literature on those subjects. The present section is devoted to the general and theoretical principles. Corrosion is discussed from the point of view of physical chemistry, and its phenomena are traced to basic principles. A valuable bibliography is given.

Der Kosteningenieur.

By F. Zeidler. Berlin, V. D. I. Verlag, 1929. 176 pp., graphs, 8 x 6 in., paper. 10.-r. m.

A discussion of the fundamentals of cost accounting, from the engineering point of view, intended for managers and operators. It discusses the purpose, processes, and results of cost accounting and points out the ways in which the engineer may make them useful to him.

Der Landmaschinenbau Heinrich Lanz A. G. Mannheim.

By M. Hofer. (Musterbetriebe Deutscher Wirtschaft,. bd 10). Berlin, S. Hirzel, 1929. 97 pp., illus., 9 x 6 in., boards. 2,75 r. m.

A well-illustrated description of the agricultural implement works of the Heinrich Lanz A.-G. at Mannheim. The origin and growth of the firm are described and the present business and operating organization explained fully.

Materials Handling Equipment.

By Edward J. Tournier. N. Y., McGraw-Hill Book Co., 1929. (Industrial Management series). 371 pp., illus., diagrs., 9 x 6 in., cloth. $4.00.

Intended as a guide to the prospective user of machinery for handling materials, this book discusses the results obtained by the use of the usual devices, the ways in which they have been adapted to different uses, and methods of selecting the proper devices for specific cases. A wide survey of current methods and equipment is provided.

Metall und Legierungskunde.

By M. v. Schwarz. 2d edition. Stuttgart, Ferdinand Enke, 1929. 383 pp., illus., diagrs., tables, 11 x 8 in., paper. 26.-r. m.

This revised and enlarged reprint of the article on metals and alloys in Dammer's "Chemische Technologie der Neuzeit" is a remarkably full, compact description of these substances. A valuable feature is an alphabetical list of three hundred common alloys, with their compositions. An exceedingly valuable work of reference.

Mineralogy.

By Sir Henry A. Miers. 2d edition revised by H. L. Bowman. Lond. & N. Y., Macmillan & Co., 1929. 658 pp., illus., diagrs., tables, 9 x 6 in., cloth. $8.50.

In this revision of Sir Henry Miers' well-known treatise, the original plan and most of the original text has been retained. The new edition is, however, about one-eighth larger than the former one, and recent advances in the subject have been incorporated throughout.

The book aims to present to the student the essential properties of minerals and the methods by which they are investigated, accompanied by a description of the more important species. The crystalline and general properties of minerals, the relationships between chemical composition and properties, the intimate structure of crystals, and the description and determination of minerals comprise the first section. In the second is a readable description of the more important species.

Practical Radio Construction and Repairing.

By James A. Moyer and John F. Wostrel. 2d edition. N. Y., McGraw-Hill Book Co., 1930. 353 pp., illus., 8 x 5 in., cloth. $2.50.

A manual of information for amateur builders, owners of radio sets, and repair men. The new edition has been revised in accordance with recent developments of the art, and a lengthy chapter on testing and repairing added. The directions are clear and practical and cover all ordinary needs.

Principles of Electrical Engineering.

By William H. Timbie and Vannevar Bush. 2d edition. N. Y., John Wiley & Sons, 1930. 595 pp., illus., diagrs., 8 x 5 in., cloth. $4.50.

A text-book for college students which is confined strictly to basic principles and is introductory to detailed courses on electrical machinery. Special features are the space given to the magnetic circuit, the free use of the electron theory, the inclusion of the subjects of thermionic emission and conduction through gases, the treatment of dielectrics and the large number of problems from practise. The authors are professors at the Massachusetts Institute of Technology.

Principles of Radio.

By Keith Henney. N. Y., John Wiley & Sons, 1929. 477 pp., illus., diagrs., tables, 8 x 5 in., cloth. $3.50.

A clear, logical presentation of radio engineering. Starting with the necessary fundamentals of electricity, the various problems of radio reception and radio apparatus are discussed in detail. The book is intended for home study, as well as for class use. Numerous problems are given. Only simple mathematics is used.

Röntgenographie der Metalle und Ihrer Legierungen.

By M. C. Neuburger. Stuttgart, Ferdinand Enke, 1929. (Sammlung chemischer und chemisch-technischer Vorträge, n. f. heft 1). 278 pp., illus., diagrs., tables, 10 x 7 in., paper. 25.-r. m.

The data on the structure of metals and alloys which various investigators have obtained by using X-rays are here summarized and presented systematically. Fifty-nine systems and twenty metals are included. A lengthy bibliography is given. The compilation will be useful to metallographists.

Selektiv-Schutzeinrichtungen für Hochspannungsanlagen.

By M. Walter. Mün. u. Ber., R. Oldenbourg, 1929. 128 pp., illus., diagrs., 9 x 6 in., paper. 7.-r. m.

A brief discussion of the comparative merits of different types of selective protective devices, with instructions for planning protective systems for high-tension lines.

Shipways to the Sea; Our Inland and Coastal Waterways.

By Ernest S. Clowes. Baltimore, Williams & Wilkins Co., 1929. 196 pp., illus., 9 x 6 in., cloth. $4.50.

Students of transportation and economics will find in this book a very convenient account of the development and present condition of American waterways. Each of the great systems is reviewed and the plans for their improvement and union into a great general system are discussed critically.

Statik der Tragwerke.

By Walther Kaufmann. 2d edition. (Handbibliothek für Bauingenieure). Berlin, Julius Springer, 1930. 322 pp., diagrs., 10 x 7 in., cloth. 19, 50 r. m.

Presents the theory of the subject as applied to both statically determinate and indeterminate structures. Does not purport to be a compendium of all possible methods of calculation, but rather to be a reference work for the practising engineer, which will meet practical needs concisely.

Technische Elektrochemie.

By Kurt Arndt. Stuttgart, Ferdinand Enke, 1929. 708 pp., illus., 10 x 7 in., paper. 52.-r. m.

A wide survey of electrochemical methods for producing and refining metals and chemicals, for plating, and for other technical purposes. The author appears to include every practical use of the present, and to give practical details in all cases. The book will be decidedly useful to metallurgists and chemists for reference.

Technische Museum als Stätten der Volksbelehrung.

By O. v. Miller. (Deutsches Museum. Abhandlungen und Berichte, bd. 1, heft 5). Berlin, V. D. I. Verlag, 1929. 27 pp., illus., 8 x 6 in., paper. 1.-r. m.

A brief discussion of the place of the technical museum in popular education, by the Director of the famous Deutsches Museum at Munich.

Thomas' Register of American Manufacturers, 20th edition, 1929-30. N. Y., Thomas Publishing Co., 1929. v. p., illus., 12 x 9 in., cloth. $15.00.

Contains lists of manufacturers in all lines, arranged alphabetically and by products; and directories of trade names, commercial organizations, banks, and trade papers. The arrangement and scope are similar to that in previous editions, but the directories have been carefully revised. The largest work of its kind, and almost indispensable.

La Transmission de la Chaleur.

By M. Ten Bosch. Trans. from the 2d German edition. Paris, Dunod, 1930. 371 pp., diagrs., tables, 10 x 7 in., paper. 90,40 fr.

Aims to present our knowledge of heat transmission in a form convenient for designers. The laws of radiation and conduction, the theory of heat transmission between two bodies, the coefficients of transmission of various substances are discussed, and the practical applications of the theory to the design of condensers and boilers explained. Numerous tables give the coefficients of heat transmission for ammonia, carbon dioxide, water, oil, steam, and other ordinary fluids.

Wärmekraft und Wärmearbeits Maschinen.

By A. Loschge. Leipzig, Akademische Verlagsgesellschaft, 1929. (Handbuch der Experimentalphysik, bd. 9, t. 2). 362 pp., illus., diagrs., tables, 10 x 7 in., cloth. 36.-r. m.

The theoretical principles of steam engines, steam and gas turbines, boilers, internal-combustion engines, compressors, and blowers are discussed in the light of recent experimental researches in this field. The book, intended for university students, is a course in the theoretical mechanics of heat engines, in which modern conceptions are presented clearly, without undue detail.

Wechselstrom-Leistungsmessungen.

By Werner Skirl. 3rd edition. Berlin, Julius Springer, 1930. 278 pp., illus., diagrs., 8 x 5 in., bound. 14.-r, m.

The principles of various kinds of wattmeters, their construction, uses, and accuracy; and the methods for measuring electric power are outlined in detail in this work.

Workshop Receipts; Supplement, Aluminum to Wireless. Lond., E. & F. N. Spon, 1930. 458 pp., illus., 7 x 5 in., cloth. 5s.

This supplement to Spon's well-known "Workshop Receipts" contains supplementary information on various topics that appear in the original four volumes, together with information on a variety of subjects not found in them. The material has been chosen for its usefulness to the craftsman and amateur.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.—W. V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

ELECTRICAL ENGINEER, experienced with power factor condensers and their use. Also, the design and development of transmitting condensers. Apply by letter. Location, New York City. X-6789.

ELECTRICAL ENGINEER, experienced in the development of volume controls for radio sets as well as development work on carbon resistors. Apply by letter. Location, New York City. X-6790.

SALES ENGINEER, graduate, capable of meeting purchasing agents and engineers. Must have good personality and initiative. Opportunity with a large manufacturer of electrical insulation. Apply by letter only, giving full qualifications, age, previous connections, initial salary, references, and preference of territory east of Mississippi. Headquarters, New York. W-468.

FELLOWSHIPS for teaching and research in the fields of civil engineering, including highway and structural engineering, electrical engineering, and mechanical engineering, including heating and ventilation. Research fellow devotes most of his service time to assigned laboratory investigations, this work is not applicable towards graduate credit or thesis. The teaching fellow assists in the instruction of students in laboratory or design courses. Stipend of each fellowship is $750 for the academic year of nine months. From the middle of September to the middle of June. This includes exemption from tuition fees. Apply only by letter. Location, Middle west. W-569-CS.

PARTNER wanted for an incorporated company dealing in optical, electrical, etc., testing and inspecting instruments for industries and institutions. Company further represents manufacturers of such instruments. Some capital required. Party interested in the proposition should have a technical training and commercial ability. Location, New Jersey. W-590.

MEN AVAILABLE

GRADUATE ELECTRICAL ENGINEER, age 34, married. Desires position as consulting engineer: preferably in foreign countries. Languages: English, Dutch, German, French. Experience: automatic telephone installation, testing and inspection, wiring and mechanical design; automatic switching and supervisory control, installation wiring design, underground and overhead line construction, surveying and estimating. C-5733.

EXECUTIVE, thoroughly qualified all phases public utilities operations. High-grade engineering, accounting, operation and regulatory commission experience. Solicits contact with those desiring services of a thoroughly qualified public utility man. C-6700.

ELECTRICAL-MECHANICAL ENGINEER, 10 years' experience design, development, manufacture a-c. and d-c. motors, generators, converters, electroplaters, elevator motors, special machines. Broad experience in application engineering. Good knowledge of modern shop practise, ability to coordinate designing, manufacturing, Well versed in German. Now employed in executive capacity. Desires position of responsibility. College graduate, 32, married. C-1801.

GRADUATE ELECTRICAL ENGINEER, 1921, desires position as designer, estimator, or sales engineer with public utility or manufacturing company. Experience in design and construction of power installations, speaks Spanish. Will start with moderate salary. New York City preferred. C-6551.

ELECTRICAL ENGINEER, 38, B. S. degree, several years' experience in design and construction of distribution and transmission systems, substations, plant and railroad installations; also operating experience. Desires new connection with greater opportunities. Now located in New England. B-998.

PUBLIC UTILITY OR SALES EXECUTIVE, 49, experienced as manager of electric public utility, including operation, engineering, sales, auditing. Organization having annual gross income $5,000,000. Also, sales division manager for one of largest electric manufacturing companies; annual sales electrical and steam apparatus, $4,000,000. Desires position with public utility or manufacturing organization. C-6817.

ELECTRICAL WORKER, central station construction or plant maintenance. Reliable references. C-6955.

FACTORY BRANCH MANAGER, 38, technical graduate, 11 years' successful experience supervising sales, installation and service operations on electrical and heating equipment. Six years' merchandizing and sales experience with nationally known company preliminary training in design and manufacture of electrical equipment. Available March first. Future with permanent organization essential. B-9231.

BLISS ELECTRICAL SCHOOL GRADUATE, age 23, single. Experience with a-c. and d-c. substation equipment, in operating department of large public utility. Desires position as assistant engineer of test. A thorough knowledge of first aid; capable of using Spanish. Location preferred, California. C-6900.

ELECTRICAL ENGINEER, 31, married. B. S. E. E. 1922. Two years' experience line, distribution with utility. Five years' charge electrical department of copper smelter. Two years in Latin America, supervisor of construction for electric utility. One year in reinforced concrete design, large copper company South West. Available on 30 days' notice. Location, immaterial. C-6962.

ELECTRICAL AND MECHANICAL ENGINEER, 37, graduate, married. Twelve years' experience covering steel maintenance on electrical equipment design and erection of electric furnaces, design and testing of cable accessories, design of transmission lines, sales work with public utilities and industrial plants. C-6851.

1929 GRADUATE, ELECTRICAL ENGINEERING, desires position which requires some application of engineering principles, and does not consist of routine work. Three months' experience in power distribution work with large power company. New York City preferred as location but willing to travel or locate elsewhere. Not interested in sales positions. C-6408.

ENGINEER EXECUTIVE: American, technical graduate, over 20 years' experience in design and construction of power plants, substations, transmission systems, including responsible management of office and field force in large organizations. Desires responsible position in similar capacity. Confidential correspondence invited. C-4852.

ELECTRICAL ENGINEER, married, graduate, 23 years' experience, electrical testing, maintainence, operating electric furnaces, high-current regulating transformers and machine shop. 15 years' superintendent graphite plant, responsible for production, engineering, organization, safety, personnel, purchasing, costs, and insurance. Position, production superintendent or plant engineer. Available at once. Location, immaterial. C-6974.

ELECTRICAL ENGINEER, age 28, single, B. S. in E. E. 1924. Five years' experience with a large public utility in economics, power studies, forecasts, and system expansion. Desires a position in a public utility or industrial concern. Location, preferably South. C-6985.

GRADUATE ELECTRICAL ENGINEER, 12 years' experience in research, development design of small apparatus. Thoroughly familiar with low-voltage (up to 220-volt) signaling, control apparatus equipment. Had charge of research, development work in two large organizations. Qualified for position calling for creative work on small apparatus. Available on short notice. C-3820.

GRADUATE ELECTRICAL ENGINEER, 29, experienced design, installation, operation power plants. Design, estimating, installation of light, power installations large buildings, projects. Five years manager, one of largest electrical contractors in East. At present consulting electrical engineer on several large buildings in South. Desires position with large company. Location, immaterial, Boston, New York City preferred. C-6918.

ELECTRICAL ENGINEER, age 39, B. S. and M. S. Union College. General Electric Test, Laboratories and consulting department five years, University teaching seven years, transformer and coil engineer two years, recently division chief. Particularly qualified for radio and allied industries, also general laboratory or teaching. C-4591.

RESEARCH ENGINEER, B. S. in Electrical Engineering and M. S. in physics, two years instruction and 4½ years' research experience. Director of research department employing 45 men. Commercial radio license. Desires employment with small manufacturing corporation as research engineer in West or Middle West. Available on short notice. C-6938.

ELECTRICAL AND MECHANICAL ENGINEER. Considerable and diversified experience in development of electromechanical devices, production methods. Independent and capable laboratory worker. Languages: German and French. Location of secondary importance. Employed at present. Available on 30 days' notice. C-6994.

ELECTRICAL ENGINEER, 1924 R. P. I. graduate. Four years assistant research engineer on insulation with the General Electric Company and 1½ years electric underground cable engineer with the Commonwealth Edison Company. Desires to relocate in eastern United States. Available upon short notice. C-4386.

ELECTRICAL ENGINEER, 32, power plant and substation design experience. Thorough knowledge of radio receiving sets. Knowledge of Russian and German. Possesses inventive and business ability. Neat draftsman, conscientious and dependable. Contributed many articles to various engineering journals on original inventions and developments. Desires position where above qualifications can be applied. B-7332.

GRADUATE ELECTRICAL ENGINEER, 30, single, seven years' experience design and construction of transmission lines, voltages up to, and including 220-kv. outdoor and indoor high-voltage substation and distribution networks. Desires position in engineering or construction department of large utility or holding company. Location immaterial. C-3564.

ELECTRICAL ENGINEER, university graduate, 40, wide knowledge of electrification including hydroelectric generation, substations, distribution, motor application, lighting, and electric furnaces. Experience covers estimates, design, and layout, construction, operation and maintenance. Desires position with power company or industry in engineering or operating divisions. B-645.

ELECTRICAL ENGINEER, university graduate, 36. Wide knowledge of electrification including generation, substations, distribution, motor application, control, lighting, etc., as applied to mining, cement mills, and other industries. Experience covers estimates, design, layout, construction, maintenance. Desires to correspond with large industrial concern requiring the services of a man of above qualifications. B-9113.

ELECTRICAL ENGINEER, 32, married, B. S., M. S. E. E. Two years' experience Indiana concern. Seven years with prominent public utilities. Desires to get in contact with prospective employer. Experienced proposal work, estimates, specifications, design, construction of central stations, transmission, distribution, railway, substations, automatic substations, overhead, underground distribution. Expert control relay work. B-6560.

TRANSMISSION ENGINEER, 36, University graduate; 13 years' experience in transmission, live field. Able to take complete charge of work. Available on limited notice. C-2014.

GRADUATE ELECTRICAL ENGINEER, 28, married, nine years' experience in engineering, construction and operation of overhead and underground distribution and transmission. Particularly fitted for economic studies, system design, phase changeovers and overhead construction. Last five years in supervisory capacities. Location, immaterial. B-9408.

ELECTROPHYSICIST, five years industrial research, development in radio, phonographs, talkies, acoustics. Formerly professor physics, research in X-rays, positive and cathode rays, photography and electric measuring instruments. Numerous patents, inventions, practical achievements above lines. Now with large concern, merger necessitates new connection with future. Wishes industrial position, professorship, or instructorship with research. C-6467.

ELECTRICAL AND MECHANICAL ENGINEER, age 33 years, married. Sixteen years' experience. Desires position as superintendent of construction or maintenance engineer. Five years as general and electrical superintendent in large electrochemical plant. Location, immaterial. Available at once. C-3671.

ELECTRICAL ENGINEER, graduate in economics, 33, German, with exceptionally broad educational background and wide American and European experience, particularly in the field of public utilities and transportation, wishes position that even at small starting salary gives opportunities of future development. Reports, investiga-

tions, research, scientific work. Linguistic abilities, business experience. C-6965.

GRADUATE ASSISTANT, 27, expects to receive M. S. degree next summer. Several years' practical experience. For position as instructor in electrical engineering. C-3202.

INDUSTRIAL ELECTRICAL ENGINEER, 38, B. S. 1916. Experienced, estimating, layout, ordering material, superintending, construction, maintenance, motors, control, power plants, switchboards, transmission lines. Can design special control apparatus, high-voltage switches, etc., take responsible charge sales engineering, construction and get friendly cooperation from all classes. Will report anywhere at once. B-9533.

AMERICAN. Two years cooperative engineering course, six months engineering department; large electrical manufacturing company. Two years assistant supervisor electrical equipment, public utility company, transmission and distribution experience. Research work, high-frequency radio. College engineering subjects, graduate and special student work; public utilities. Location, immaterial, South American countries. preferred. Available two weeks. C-7017.

ELECTRICAL ENGINEER, 32, married, 12 years' experience, design, layout, construction, maintenance, repair large industrials, three years modern, custom repair shop practise. Thoroughly familiar modern power equipment, repair shop practise, mass production requirements. Desires responsible connection large utility, industrial plant, large repair shop. Can effect appreciable economies in repair shop practise. Middle western location preferred. C-5916.

ASSISTANT EXECUTIVE, 38, married, technically trained. Connections with large public utility, manufacturers and industrial consultants on work of administrative and commercial nature. Especially qualified as assistant to busy executive needing man with management ability. Well endorsed. Prefers East. B-9122.

ELECTRICAL-MECHANICAL ENGINEER, Cornell. G. E. and locomotive shops. Six years in each of the following lines: trunk railway electrification, hydroelectric irrigation projects, heavy automotive equipment operation, preparation of technical reports, South America and Orient. Commercial production high-tension vacuum devices, X-ray, neon tubes, plant equipment. Director Electrophysical laboratory research. C-7026.

ELECTRICAL ENGINEER, 9 years' engineering experience. Experience coves design and construction of overhead distribution and transmission systems; underground a-c. networks and distribution systems; switchboard and substation design and operation. Executive ability. At present assistant distribution engineer. Location, Southwest or South. C-4734.

ELECTRICAL ENGINEERING ASSISTANT, 26, married, college graduate. Four years' transmission and distribution experience with public utilities on design, estimates, survey, and valuation. Desires connection with public utility engineering department. New York City location preferred, but will consider any United States location. C-5511.

RADIO ENGINEER, married, eight years' executive experience in design, operating and maintenance of broadcasting stations. B. A. degree in science. Studies in several colleges and universities. Have traveled extensively. Desires an executive position with large broadcasting station; with talking picture industry, or allied fields. Well endorsed. C-7040.

ELECTRICAL ENGINEER, receiving Doctor of Engineering in May. Research laboratory experience. Completed Westinghouse Graduate Students Course. Excellent knowledge of Russian; reading knowledge of German and French. Desires teaching position in reputable institution. Willing to consider commercial development and research. Eastern or Central Eastern States preferred. Available June 1930. C-7011.

ELECTRICAL ENGINEER, 30, technical graduate, single. One year electrical construction and five years electrical design drafting with large utilities or substation and power station design. Desires connection preferably with utility with opportunity for advancement in engineering electrical station design. Now employed. C-7043.

ELECTRICAL ENGINEER, M. I. T. graduate, 34, married, desires teaching position in college E. E. course beginning next fall. Six years' research and industrial experience including G. E. Co. and Bureau of Standards. Two years' teaching experience. Best of references. Middle West or South preferred. C-2826.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher then Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before March 31, 1930.

Adelson, H., General Electric Co., Schenectady, N. Y.
Aicholtz, L. A., Electrical Research Products, Inc., Hollywood, Calif.
Alber, E. A., Teletype Corp., Chicago, Ill.
Allen, R. M., (Member), Jackson & Moreland, Hoboken, N. J.
Arberry, J. P., Pittsburgh Plate Glass Co., Pittsburgh, Pa.
Barnes, C., Van Schaack Chemical Works, Chicago, Ill.
Barnet, G. R., New York & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
Bates, A. E., Western Electric Co., Kearny, N. J.
Baumgartner, A. B., Public Service Co. of Colo., Denver, Colo.
Benjamin, Abraham, Montreal Light, Heat & Power Co., Montreal, Que., Can.
Benjamin, Archie, Montreal Light, Heat & Power Cons., Montreal, Que., Can.
Bennett, P. A., Public Service Co. of Northern Illinois, Chicago, Ill.
Bergman, J., Jr., New Jersey Bell Telephone Co., Hackensack, N. J.
Bird, G. T., Bird-Potts Company, Inc., Atlanta, Ga.
Bivenour, C. A., Ohio Power Co., Coshocton, Ohio
Blackhall, H. J., Western Electric Co., Kearny, N. J.
Blanchard, R. F., (Member), Western Union Tel. Co., New York, N. Y.
Bley, W. B., New York Central Railroad, New York, N. Y.
Blugerman, L. N., United Engineers & Constructors, Inc., Philadelphia, Pa.
Breslauer, W., Jackson & Moreland, Hoboken, N. J.
Brosler, E., (Member), Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Brown, R. W., Western Electric Co., Chicago, Ill
Brown, V. J., J. Leo Scanlon Co., Buffalo, N. Y.
Bumstead, R. W., International Communications Laboratories, Inc., New York, N. Y.
Butler, E. J., New York & Queens Elec. Lt. & Pr. Co., Long Island City, N. Y.
Carnahan, R. W., Paramount Fire Alarm Engineering Co., Cleveland, Ohio
Carpenter, G. M., Charles H. Tenney & Co., Boston, Mass.
Chapman, J. H., Jr., Hall Electric Heating Co., Inc., Philadelphia, Pa.
Chesley, A. D., U. S. Post Office, Falls City, Nebr.
Childs, J. R., Duquesne Light Co., Pittsburgh, Pa.
Clarke, H. J., Duquesne Light Co., Rochester, Pa.
Colby, M. E., Western Electric Co., Newark, N. J.
Collings, J. V., Commonwealth Edison Co., Chicago, Ill.
Cotton, A. R., Public Service Co. of Northern Illinois, Chicago, Ill.
Cotton, R. L., New York Edison Co., New York, N. Y.
Cox, F. A., Public Service Co. of Northern Illinois, Chicago, Ill.
Cress, W. M., Public Service Co. of Northern Illinois, Chicago, Ill.
Crimmin, E. V., Edison Electric Illuminating Co. of Boston, Boston, Mass
Daffron, R. C., Virginia Electric & Power Co., Richmond, Va.
Davis, E. G., Duquesne Light Co., Pittsburgh, Pa.
Dentler, J. W., General Electric Co., Erie, Pa.
DeWitt, H. M., Westchester Lighting Co., Rye, N. Y.
Diamond, H., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Duncan, T. C., N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
Ehrensperger, C., American Brown Boveri Co., Camden, N. J.
Elfast, R. E., New York & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
Elgin, R. P., Keystone Public Service Co., Oil City, Pa.
Ely, H. B., (Member), Bell Telephone Laboratories, Inc., New York, N. Y.
English, T. O., Alcoa Ore Co., East St. Louis, Ill.
Eschbach, D. O., Philadelphia & Reading Coal & Iron Co., Pottsville, Pa.
Etienne, L. A., Westinghouse Elec. & Mfg. Co., Denver, Colo
Fordham, L. D., Public Service Co. of Northern Illinois, Chicago, Ill.
Foster, C. W., 24 Astor Drive, Rochester, N. Y.
Freeland, C. M., Worcester Electric Light Co., Worcester, Mass.
Fuller, S. J., New York & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
Garnhart, G. E., Brooklyn Edison Co., Brooklyn, N. Y.
Garrett, J. B., Jr., Yonkers Electric Lt. & Pr. Co., Yonkers, N. Y.
Gerbracht, C. J., General Electric Co., Erie, Pa.
Gilles, P. F., Cleveland Railway Co., Cleveland, Ohio
Gillette, R. W., New York & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
Goldsborough, T. R., (Member), Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Gordon, K. E., Charles H. Tenney & Co., Boston, Mass
Graham, H. J., Schenectady Varnish Co., Schenectady, N. Y.
Graul, T. A., Bell Telephone Co. of Penna., Pittsburgh, Pa.
Guenther, W. M., Cleveland Railway Co., Cleveland, Ohio
Haas, P., Moto Meter Gauge & Equipment Co., Toledo, Ohio
Hale, P. W., United Electric Light & Power Co., New York, N. Y.

Haley, L. A., Graybar Electric Co., Houston, Tex.
Hamilton, A. E., Hydro Electric Power Commission of Ontario, Toronto, Ont., Can.
Hanaoka, K., Japanese Government Railways, New York, N. Y.
Harness, G. T., Jr., College of the Pacific, Stockton, Calif.
Havourd, R. M., Public Service Elec. & Gas Co., Newark, N. J.
Hedin, F. H., Jackson & Moreland, Hoboken, N. J.
Henkel, G. E., School of Engineering of Milwaukee, Milwaukee, Wis.
Hill, J. F., Saskatchewan Power Commission, Regina, Sask., Can.
Hoffman, G. M., Jr., Jackson & Moreland, Hoboken, N. J.
Hoffman, G. N., Duquesne Light Co., Pittsburgh, Pa.
Horst, J. S., Edison Electric Co., Sinking Spring, Pa.
Hurt, M. J., Southern California Edison Co., Big Creek, Calif.
Isbell, G. T., Isbell's, Jacksboro, Tex.
James, R. L., Pennsylvania Power Co., Sharon, Pa.
Jillson, C. F., Public Service Co. of Northern Illinois, Chicago, Ill.
Johnson, A., Brooklyn Edison Co., Brooklyn, N. Y.
Joseph, J. S., Southwestern Bell Tel. Co., Oklahoma City, Okla.
Kellems, V.; Kellems Products, Inc., New York, N. Y.
King, P. E., Midland Counties Public Service Corp., Coalinga, Calif.
King, R. T., Public Service Elec. & Gas Co. of N. J., Burlington, N. J.
Klinger, M. E., Erie Lighting Co., Erie, Pa.
Kobayashi, I., Ryobi Denki Shokai, Ltd., c/o Mitsubishi Shoji Kaisha, Ltd., New York, N. Y.
Kron, G., Lincoln Electric Co., Cleveland, Ohio
Lamantia, A. J., New York Edison Co., New York, N. Y.
Lay, R. L., Geophysical Research Corp., Houston, Tex.
Leidigh, W. A., Jr., Portland Electric Power Co., Portland, Ore.
Lesh, S. S., Pennsylvania Power & Light Co., Allentown, Pa.
Lidemark, K., Pacific Gas & Electric Co., San Francisco, Calif.
Mabey, C. A., International Communications Laboratories, Inc., New York, N. Y.
Markley, F. H., General Electric Co., Erie, Pa.
Marshall, S. W., Southwestern Bell Telephone Co., Houston, Tex.
Martin, W. G., Jr., National Broadcasting Co., New York, N. Y.
Masters, J. C., Cleveland Railway Co., Cleveland, Ohio
Masters, T. J., Montreal Light, Heat & Power Consolidated, Montreal, Que., Can.
Mazumdar, B. C., General Electric Co., Schenectady, N. Y.
McDowell, L. G., New York & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
McGrath, H. O., Bell Tel. Co. of Penna., Pittsburgh, Pa.
McKay, F. A., Lyman Tube & Supply Co., Ltd., Montreal, Que., Can.
Mosley, C. E., Union Electric Light & Power Co., St. Louis, Mo.
Moss, S. A., Chesapeake & Potomac Telephone Co., Washington, D. C.
Murray, W. R., Westinghouse Elec. & Mfg. Co., New York, N. Y.
Neil, J. L., Pathé Studios, Culver City, Calif.
Neville, W. H., 829 Martin Bldg., Birmingham, Ala.
(Applicant for re-election.)
Nichols, M. C., Worcester Electric Light Co., Worcester, Mass.
Nordstedt, E. A., Public Service Co. of Northern Illinois, Chicago, Ill.
Oliver, T. S., Public Service Co. of Colo., Denver, Colo.
Olson, B. R., General Railway Signal Co., Rochester, N. Y.
O'Neill, C. F., (Member), Westinghouse Elec. & Mfg. Co., New York, N. Y.
Orr, W. W., Canadian General Electric Co., Toronto, Ont., Can.
Pagesy, C. H., Pennsylvania Railroad, Philadelphia, Pa.
Patterson, L. R., Public Service Co. of Colorado, Denver, Colo.
Porter, M. O., Jr., Delos G. Haynes, St. Louis, Mo.
Prescott, J. O., (Member), Columbia Phonograph Co., Inc., New York, N. Y.
Prososki, M., General Electric Co., Erie, Pa.
Prow, A. H., Strawbridge & Clothier, Philadelphia, Pa.
Quigley, J. H., Falls City Motor Co., Falls City, Nebr.
Rall, J., Board of Transportation, City of New York, New York, N. Y.
Read, C. A., General Electric Co., Pittsfield, Mass.
Reber, J. G., Metropolitan Edison Co., Easton, Pa.
Reinovsky, E., Standard Underground Cable Co., Perth Amboy, N. J.
Rice, A. J., National Broadcasting Co., New York, N. Y.
Richardson, R. M., Public Service Co. of Colo., Denver, Colo.
Roisland, K., Western Electric Co., Inc., Kearny, N. J.
Rolston, G. E., Rome Wire Co., Philadelphia, Pa.
Rosier, R., Monongahela West Penn Public Service Co., Fairmont, W Va.
Samuels, R. C., General Electric Co., Philadelphia, Pa.
Sawyer, E. B., Railway & Industrial Engineering Co., Denver, Colo.
Schlemmer, O. C., Cincinnati & Suburban Bell Tel. Co., Cincinnati, Ohio
Schrimser, T. J., Benolite Varnish Co., Pittsburgh, Pa.
Schultz, G. J., Public Service Co. of Northern Illinois, Waukegan, Ill.
Schuster, A. L., Hoover Co., North Canton, Ohio
Shen, C., International General Electric Co., Schenectady, N. Y.
Shildneck, L. P., General Electric Co., Schenectady, N. Y.
Silzle, L. W., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Smith, E. C., Ohio Bell Telephone Co., Akron, Ohio
Solberg, G., Western Electric Co., Kearny, N. J.
Steinert, E. E., General Electric Co., Schenectady, N. Y.
Stewart, O. V., Benolite Varnish Co., Pittsburgh, Pa.
Strong, E. A., James Richardson & Sons, Ltd., Fleming, Sask., Can.
Strong, J. E., Illinois Power & Light Corp., East St. Louis, Ill.
Sugiyama, K., c/o Mitsui & Co., New York, N. Y.
Sumner, W. A., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Swanson, S. V., Public Service Co. of Northern Illinois, Chicago, Ill.
Tapy, R. W., University of Detroit, Detroit, Mich.
Taylor, J. M., City of Saskatoon, Saskatoon, Sask., Can.
Theis, A. R., (Member), Westinghouse Elec. & Mfg. Co., Brooklyn, N. Y.
Tinnerholm, R. F., General Electric Co., Philadelphia, Pa.
Tompkins, J., Nantahala Power & Light Co., Andrews, N. C.
Towey, J. M., Chicago, Milwaukee, St. Paul & Pacific Railway. Deer Lodge, Mont.
Tyrrell, W. L., Brown Instrument Co., Philadelphia, Pa.
Ulanet, H., Federal Steel Products Co., Newark, N. J.
Van Brocklin, F., RCA Photophone, Inc., Chicago, Ill.
Van Hennik, E., New York Telephone Co., New York, N. Y.
Vickerman, C. E., City of Philadelphia, Philadelphia, Pa.
von Rohrscheidt, O. K., (Member), Vera Cruz Light, Power & Traction Co., Ltd., Vera Cruz, Ver., Mexico
Wagner, H. J., Duquesne Light Co., Pittsburgh, Pa.
Wagoner, K. S., Electrical Engineers Equipment Co., Melrose Park, Ill.
Wahlgren, W. W., Gardner Electric Mfg. Co., Emeryville, Calif.
Welhoelter, M., Illinois Power & Light Corp., East St. Louis, Ill.
Whipple, W. N., Phoenix Utility Co., Salt Lake City, Utah
Whitehead, E. R., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Whiteman, C. A., (Member), Erie Lighting Co., Erie, Pa.
Wirts, C. C., Jr., Illinois Power & Light Corp., East St. Louis, Ill.
Yetter, P. A., Public Service Co. of Colo., Denver, Colo.
Ziegenfuss, H. E., Public Service Elec. & Gas Co., Irvington, N. J.
Total 172

Foreign

Booth. W. M., English Electric Co., Marunouchi, Tokyo, Japan
Briggs, C. H., Melton House, Melton, E. Yorkshire, Eng.
Dean, G., Sydney Municipal Council, Sydney, Australia
Hall, F. P. W., Callender's Cable & Construction Co., Ltd., Erith, Kent, Eng.
Hochstadter, M., (Member), 10 Place Madon, Brussels, Belgium
Hutter, H. E., General Electric Co., Ltd., Witton, Birmingham, Eng.
Leduc, M., Lignes Telegrapiquesh et Telephoniques, Paris, France
Suemitsu, T., Fujikura Densen K. K., Tokyo City, Japan
Total 8

OFFICERS A. I. E. E. 1929-1930

President
HAROLD B. SMITH

Junior Past Presidents
R. F. SCHUCHARDT
BANCROFT GHERARDI

Vice-Presidents
E. B. MERRIAM
H. A. KIDDER
W. T. RYAN
B. D. HULL
G. E. QUINAN
HERBERT S. EVANS
W. S. RODMAN
C. E. FLEAGER
E. C. STONE
C. E. SISSON

Directors
I. E. MOULTROP
H. C. DON CARLOS
F. J. CHESTERMAN
F. C. HANKER
E. B. MEYER
H. P. LIVERSIDGE
J. ALLEN JOHNSON
A. M. MACCUTCHEON
A. E. BETTIS
W. S. LEE
J. E. KEARNS
C. E. STEPHENS

National Treasurer
GEORGE A. HAMILTON

National Secretary
F. L. HUTCHINSON

General Counsel: PARKER & AARON
30 Broad Street, New York

LOCAL HONORARY SECRETARIES

T. J. Fleming, Calle B. Mitre 519, Buenos Aires, Argentina, S. A.
H. W. Flashman, Aus. Westinghouse Elec. Co. Ltd., Cathcart House, 11 Castlereagh St., Sydney, N. S. W., Australia.
F. M. Servos, Rio de Janiero Tramways, Light & Power Co., Rio de Janeiro, Brazil.
A. P. M. Fleming, Metropolitan Vickers Elec. Co., Trafford Park, Manchester, England.
A. S. Garfield, 45 Bd. Beausejour, Paris 16 E., France.
F. W. Willis, Tata Power Company, Bombay House, Bombay, India.
P. H. Powell, Canterbury College, Christchurch, New Zealand.
M. Chatelain, Lesnoi Polytechnic Institute, Apt. 27, Leningrad, U. S. S. R.
Axel F. Enstrom, 24a Ingeniorsvetenskrapsakademien, Stockholm, 5 Sweden.
W. Eldson-Dew, P. O. Box 4563 Johannesburg, Transvaal, Africa.

A. I. E. E. COMMITTEES

(A list of the personnel of Institute committees may be found in the January issue of the JOURNAL.)

GENERAL STANDING COMMITTEES AND CHAIRMEN

EXECUTIVE, Harold B. Smith
FINANCE, E. B. Meyer
MEETINGS AND PAPERS, A. E. Knowlton
PUBLICATION, W. S. Gorsuch
COORDINATION OF INSTITUTE ACTIVITIES, H. A. Kidder
BOARD OF EXAMINERS, E. H. Everit
SECTIONS, W. B. Kouwenhoven
STUDENT BRANCHES, W. H. Timbie
MEMBERSHIP, J. Allen Johnson
HEADQUARTERS, R. H. Tapscott
LAW, L. F. Morehouse
PUBLIC POLICY, D. C. Jackson
STANDARDS, F. D. Newbury
EDISON MEDAL, Samuel Insull
LAMME MEDAL, Charles F. Scott
CODE OF PRINCIPLES OF PROFESSIONAL CONDUCT, F. B. Jewett
COLUMBIA UNIVERSITY SCHOLARSHIPS, W. I. Slichter
AWARD OF INSTITUTE PRIZES, A. E. Knowlton
SAFETY CODES, A. W. Berresford

SPECIAL COMMITTEE

ADVISORY COMMITTEE TO THE MUSEUMS OF THE PEACEFUL ARTS, J. P. Jackson

TECHNICAL COMMITTEES AND CHAIRMEN

AUTOMATIC STATIONS, F. Zogbaum
COMMUNICATION, G. A. Kositzky
EDUCATION, Edward Bennett
ELECTRICAL MACHINERY, Philip L. Alger
ELECTRIC WELDING, A. M. Candy
ELECTROCHEMISTRY AND ELECTROMETALLURGY, P. H. Brace
ELECTROPHYSICS, O. E. Buckley
GENERAL POWER APPLICATIONS, J. F. Gaskill
INSTRUMENTS AND MEASUREMENTS, Everett S. Lee
APPLICATIONS TO IRON AND STEEL PRODUCTION, M. M. Fowler
PRODUCTION AND APPLICATION OF LIGHT, George S. Merrill
APPLICATIONS TO MARINE WORK, W. E. Thau
APPLICATIONS TO MINING WORK, Carl Lee
POWER GENERATION, F. A. Allner
POWER TRANSMISSION AND DISTRIBUTION, H. R. Woodrow
PROTECTIVE DEVICES, E. A. Hester
RESEARCH, S. M. Kintner
TRANSPORTATION, Sidney Withington

A. I. E. E. REPRESENTATION

(The Institute is represented on the following bodies; the names of the representatives may be found in the January issue of the JOURNAL.)

ALFRED NOBLE PRIZE COMMITTEE, A. S. C. E.
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, COUNCIL
AMERICAN BUREAU OF WELDING
AMERICAN COMMITTEE ON ELECTROLYSIS
AMERICAN ENGINEERING COUNCIL ASSEMBLY
AMERICAN MARINE STANDARDS COMMITTEE
AMERICAN STANDARDS ASSOCIATION
AMERICAN YEAR BOOK, ADVISORY BOARD
CHARLES A. COFFIN FELLOWSHIP AND RESEARCH FUND COMMITTEE
COMMITTEE OF APPARATUS MAKERS AND USERS, NATIONAL RESEARCH COUNCIL
COMMITTEE ON ELIMINATION OF FATIGUE, SOCIETY OF INDUSTRIAL ENGINEERS
COMMITTEE ON HEAT TRANSMISSION, NATIONAL RESEARCH COUNCIL
ENGINEERING FOUNDATION, INC.
ENGINEERING SOCIETIES RESEARCH BOARD
JOHN FRITZ MEDAL BOARD OF AWARD
JOINT COMMITTEE ON WELDED RAIL JOINTS
JOINT CONFERENCE COMMITTEE OF FOUR FOUNDER SOCIETIES
LIBRARY BOARD, ENGINEERING FOUNDATION, INC.
NATIONAL FIRE PROTECTION ASSOCIATION, ELECTRICAL COMMITTEE
NATIONAL FIRE WASTE COUNCIL
NATIONAL RESEARCH COUNCIL, ENGINEERING DIVISION
NATIONAL SAFETY COUNCIL, ELECTRICAL COMMITTEE OF A. S. S. E.—ENGINEERING SECTION
RADIO ADVISORY COMMITTEE, BUREAU OF STANDARDS
SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, BOARD OF INVESTIGATION AND COORDINATION
U. S. NATIONAL COMMITTEE OF THE INTERNATIONAL COMMISSION ON ILLUMINATION
U. S. NATIONAL COMMITTEE OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION
WASHINGTON AWARD, COMMISSION OF

GEOGRAPHICAL DISTRICT EXECUTIVE COMMITTEES

District	Chairman (Vice-President, A. I. E. E.)	Secretary (District Secretary)
No. 1—North Eastern	E. B. Merriam, General Electric Co., Schenectady, N.Y.	A. C. Stevens, General Electric Co., Schenectady, N. Y.
No. 2—Middle Eastern	E. C. Stone, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa.	J. A. Cadwallader, Bell Tel. Co. of Penna., 416 Seventh Ave. Pittsburgh, Pa.
No. 3—New York City	H. A. Kidder, 600 West 59th Street, New York, N. Y.	J. B. Bassett, General Electric Co., 120 Broadway, New York, N. Y.
No. 4—Southern	W. S. Rodman, Box 675, University, Va.	J. S. Miller, Jr., Box 12, University, Va.
No. 5—Great Lakes	W. T. Ryan, University of Minnesota, Minneapolis, Minn.	A. G. Dewars, Northern States Power Co., St. Paul, Minn.
No. 6—North Central	Herbert S.Evans, University of Colorado, Boulder, Colo.	M. S. Coover, University of Colorado, Boulder, Colo.
No. 7—South West	B. D. Hull, Southwestern Bell Tel. Co., Dallas, Tex.	A. E. Allen, 1801 North Lamar St., Dallas, Tex.
No. 8—Pacific	C. E. Fleager, Pacific Tel. & Tel. Co., 140 New Montgomery St., San Francisco, Calif.	H. W. Hitchcock, 1050 Telephone Building, 740 South. Olive St., Los Angeles, Calif.
No. 9—North West	G. E. Quinan, Box 1879, Seattle, Wash.	J. Hellenthal, Puget Sound Pr. & Lt. Co., Seattle, Wash.
No. 10—Canada	C. E. Sisson, Canadian General Electric Co., 1025 Lansdowne Ave., Toronto, Ont.	W. L. Amos, Hydro-Elec. Power Commission, 190 University Ave., Toronto, Ont.

Note: Each District Executive Committee includes the chairmen and secretaries of all Sections within the District and the chairman of the District Committee on Student Activities.

LIST OF SECTIONS

Name	District	Chairman	Secretary
Akron	(2)	W. A. Hillebrand	R. R. Krammes, The Ohio Power Co., Canton, O.
Atlanta	(4)	H. L. Wills	W. F. Bellinger, Electric Bldg., Atlanta, Ga.
Baltimore	(2)	W.B.Kouwenhoven	G. S. Diehl, Pa. Water & Pwr. Co., 1611 Lexington Bldg., Baltimore, Md.
Birmingham	(4)	W. E. Bare	O. E. Charlton, Alabama Power Co., Birmingham, Ala.
Boston	(1)	W. H. Colburn	G. J. Crowdes, Simplex Wire & Cable Co., Sidney St., Cambridge, Mass.
Chicago	(5)	T. G. LeClair	F. R. Innes, c/o Electrical World, 7 So. Dearborn St., Chicago, Ill.
Cincinnati	(2)	T. C. Reed	L. L. Bosch, Columbia Engg. & Mgmt. Corp., 314 West 4th St., Cincinnati, O.
Cleveland	(2)	T. D. Owens	Wm. H. LaMond, Simplex Wire & Cable Co., 2019 Union Trust Bldg., Cleveland, O.
Columbus	(2)	R. A. Brown	C. D. Price, 87 East Blake Avenue, Columbus, Ohio
Connecticut	(1)	Sidney Withington	R. G. Warner, Yale Univ., New Haven, Conn.
Dallas	(7)	J. B. Thomas	A. Chetham-Strode, Dallas Pwr. & Light Co., Interurban Bldg., Dallas, Tex.
Denver	(6)	W. H. Bullock	N. R. Love, 807 Tramway Bldg., Denver, Colo.
Detroit-Ann Arbor	(5)	L. F. Hickernell	T. N. Lacy, Michigan Bell Tel. Co., 1365 Cass Ave., Detroit, Mich.
Erie	(2)	W. H. Pelton	Geo. I. Le Baron, General Electric Co., Erie, Pa.
Fort Wayne	(5)	F. W. Merrill	E. J. Schaefer, General Electric Co., Ft. Wayne, Ind.
Houston	(7)	L. K. Del'Homme	C. D. Farman, Southwestern Bell Tel. Co., Houston, Texas
Indianapolis-Laf.	(5)	J. B. Bailey	H. M. Stradling, 353 Mass Ave., Indianapolis, Ind.
Iowa	(5)	C. L. Sampson	J. K. McNeely, Iowa State College, Ames, Iowa
Ithaca	(1)	W. C. Ballard, Jr.	W. E. Meserve, 614 E. Buffalo St., Ithaca, N. Y.
Kansas City	(7)	A. B. Covey	J. S. Palmer, Kansas City Pr. & Lt. Co., 1330 Grand Ave., Kansas City, Mo.
Lehigh Valley	(2)	A. J. Althouse	E. F. Weaver, Pa. Pr. & Lt. Co., 901 Hamilton St., Allentown, Pa.
Los Angeles	(8)	N. B. Hinson	H. W. Hitchcock, So. Cal. Tel. Co., 740 So. Olive St., Los Angeles, Cal.
Louisville	(4)	H. W. Wischmeyer	Philip P. Ash, Louisville & Nashville Rd. Bldg., 9th & B'way Ave., Louisville, Ky.
Lynn	(1)	I. F. Kinnard	H. K. Nock, General Elec. Co., West Lynn, Mass.
Madison	(5)	R. E. Purucker	L. C. Larson, Univ. of Wisconsin, Madison, Wis.
Mexico	(3)	G. Solis-Payan	E. Leonarz, Jr., Apartado, 2601, Mexico City, Mexico
Milwaukee	(5)	E. W. Seeger	R. C. Siegel, Wisconsin Tel. Co., 418 Broadway, Milwaukee, Wis.
Minnesota	(5)	V. E. Engquist	Oscar Gaarden, Northern State Pr. Co., 15 S. 5th St., Minneapolis, Minn.
Nebraska	(6)	D. H. Braymer	W. O. Jacobi, Omaha & Council Bluffs St. Ry. Co., 19 & Farnam Sts., Omaha, Neb.
New York	(3)	H. P. Charlesworth	T. F. Barton, General Elec. Co., 120 Broadway, New York
Niagara Frontier	(1)	Raymond T. Henry	E. P. Harder, Buffalo General Elec. Co., 205 Electric Bldg., Buffalo, N. Y.
North Carolina	(4)	E. P. Coles	Marshall E. Lake, Duke Pr. Co. Power Bldg., Charlotte, N. C.
Oklahoma City	(7)	C. Walker Mier	C. T. Almquist, Univ. of Oklahoma, Norman, Okla.
Panama	(3)		
Philadelphia	(2)	R. H. Silbert	J. L. MacBurney, Elec. Storage Battery Co., 1955 Hunting Park Ave., Philadelphia, Pa.
Pittsburgh	(2)	J. A. Cadwallader	C. T. Sinclair, Byllesby Engg. & Mngmt. Corp., 435 Sixth Ave., Pittsburgh, Pa.
Pittsfield	(1)	L. F. Blume	L. H. Burnham, General Electric Co., Pittsfield, Mass.
Portland, Ore.	(9)	H. H. Cake	A. H. Kreul, Portland Elec. Pr. Co., Hawthorne Bldg., Portland, Ore.
Providence	(1)	F. W. Smith	O. W. Briden, Blackstone Valley Gas & Elec. Co., Pawtucket, R. I.
Rochester	(1)	Virgil M. Graham	Charles F. Estwick, General Railway Signal Co., Rochester, N. Y.
St. Louis	(7)	G. H. Quermann	O. J. Rotty, Union Elec. Lt. & Pr. Co., 315 No. 12th Blvd., St. Louis, Mo.
San Francisco	(8)	L. F. Fuller	G. Ross Henninger, Electrical West, 883 Mission St., San Francisco, Cal.
Saskatchewan	(10)	J. R. Cowley	A. B. Coward, Light & Power Dept., Regina, Sask., Canada
Schenectady	(1)	R. Treat	E. E. Johnson, Rm. 435, Bldg. 2, General Electric Co., Schenectady, N. Y.
Seattle	(9)	L. N. Robinson	George S. Smith, Elec. Engg. Dept., University of Washington, Seattle, Wash.
Sharon	(2)	J. B. Gibbs	S. S. Cook, Westinghouse E. & M. Co., Sharon, Pa.
Southern Virginia	(4)	H. C. Leonard	Cecil Gray, Westinghouse E. & M. Co., 912 Electric Bldg., Richmond, Va.
Spokane	(9)	Earl Baughn	Loren A. Traub, 215 Symons Bldg., Spokane, Wash.
Springfield, Mass.	(1)	Fred L. Hunt	B. V. K. French, American Bosch Magneto Corp., Springfield, Mass.
Syracuse	(1)	F. E. Verdin	Chas. W. Henderson, 504 University Pl., Syracuse, N. Y.
Toledo	(2)	E. B. Featherstone	Max Neuber, 1257 Fernwood Ave., Toledo, O.
Toronto	(10)	F. F. Ambuhl	W. F. Sutherland, Toronto Hydroelec. Sys., 225 Yonge St., Toronto, Ont., Canada
Urbana	(5)	M. A. Faucett	C. E. Skroder, Univ. of Ill., Urbana, Ill.
Utah	(9)	A. C. Kelm	L. B. Fuller, Utah Pr. & Lt. Co., Salt Lake City, Utah
Vancouver	(10)	J. Teasdale	D. Robertson, Canadian Gen. Elec. Co., Ltd., Vancouver. B. C., Canada
Washington	(2)	W. A. E. Doying	G. L. Weller, Chesapeake & Potomac Tel. Co. & Assoc. Cos., 725-13th St., N. W., Washington, D. C.
Worcester	(1)	H. H. Newell	R. P. Bullen, General Elec. Co., 704 State Mutual Bldg., Worcester, Mass.
Total 57			

LIST OF BRANCHES

Name and Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Akron, Municipal Univ. of, Akron, Ohio	(2)	Glenn O. Hite	G. G. Clark	J. T. Walther
Alabama Polytechnic Inst., Auburn, Ala	(4)	R. F. Ham	G. A. Beavers	W. W. Hill
Alabama, Univ. of, University, Ala	(4)	R. M. Phillips		
Arizona, Univ. of, Tucson, Ariz	(8)	Barney Shehane	F. F. Denney	J. C. Clark
Arkansas, Univ. of, Fayetteville, Ark	(7)	D. J. Morrison	E. Wylie Head	W. B. Stelzner
Armour Inst. of Tech., 3300 Federal St., Chicago, Ill	(5)	J. Dollenmaier	S. Janiszewski	E. H. Freeman
Brooklyn Poly. Inst., 99 Livingston St., Brooklyn, N. Y	(3)	F. J. Mullen	R. G. O'Sullivan	Clyde C. Whipple
Bucknell University, Lewisburg, Pa	(2)	E. C. Metcalf	R. G. Tingle	W. K. Rhodes
Calif. Inst. of Tech., Pasadena, Calif	(8)	E. C. Lee	J. L. Hall	R. W. Sorensen
Calif., Univ. of, Berkeley, Calif	(8)	Frank R. Norton	Arthur G. Forster	L. E. Reukema
Carnegie Inst. of Tech., Pittsburgh, Pa	(2)	J. R. Britton	S. A. Bottonari	B. C. Dennison
Case School of Applied Science, Cleveland, Ohio	(2)	R. B. McIntosh	H. L. Brouse	H. B. Dates
Catholic Univ. of America, Washington, D. C	(2)	T. J. Dunn	E. C. McCleery	Thos.J.MacKavanaugh
Cincinnati, Univ. of, Cincinnati, Ohio	(2)	V. G. Rettig	R. D. Bourne	W. C. Osterbrock
Clarkson College of Tech., Potsdam, N. Y	(1)	R. N. Roberts	F. W. Truesdell	A. R. Powers
Clemson Agri. College, Clemson College, S. C	(4)	G. W. Sackman	Walter C. Snyder	Sam. R. Rhodes
Colorado State Agri. College, Ft. Collins, Colo	(6)	G. R. Branch	L. Haubrich	H. G. Jordan

LIST OF BRANCHES—*Continued*

Name and Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Colorado, University of, Boulder, Colo	(6)	Wm. J. Dowis	George B. Steuart	W. C. DuVall
Cooper Union, New York, N. Y.	(3)	H. Reuter	H. Grissler	A. J. B. Fairburn
Cornell University, Ithaca, N. Y.	(1)	Alexander B. Credle	J. D. McCurdy	Everett M. Strong
Denver, Univ. of, Denver, Colo	(6)	L. J. Wright	R. B. Convery	R. E. Nyswander
Detroit, Univ. of, Detroit, Mich	(5)	Wm. F. Haldeman	W. R. Moyers	H. O. Warner
Drexel Institute, Philadelphia, Pa	(2)	E. K. Cliver	G. R. Bowers	E. O. Lange
Duke University, Durham, N. C.	(4)	R. H. Stearns	H. M. Sherard	W. J. Seeley
Florida, Univ. of, Gainesville, Fla	(4)	J. W. McKay	A. L. Webb	J. M. Weil
Georgia School of Tech., Atlanta, Ga	(4)	Lee B. Mann	J. W. Hall	T. W. Fitzgerald
Idaho, University of, Moscow, Idaho	(9)	Wayne McCoy	C. E. Conway	J. H. Johnson
Iowa State College, Ames, Iowa	(5)	H. H. Stahl	H. Kirk	F. A. Fish
Iowa State University of, Iowa City, Iowa	(5)	T. F. Taylor	L. N. Miller	E. B. Kurtz
Kansas State College, Manhattan, Kansas	(7)	L. N. Lydick	L. C. Paslay	R. M. Kerchner
Kansas, Univ. of, Lawrence, Kansas	(7)	M. W. Hammond	H. W. Yenzer	G. C. Shaad
Kentucky, Univ. of, Lexington, Ky	(4)	Wm. F. Steers	R. I. Fort	W. E. Freeman
Lafayette College, Easton, Pa	(2)	E. C. Albert	Wm. F. Titus	Morland King
Lehigh University, Bethlehem, Pa	(2)	B. O. Steinert	J. E. Zeaser	J. L. Beaver
Lewis Institute, Chicago, Ill	(5)	G. W. Malstrom	E. R. Borden	F. A. Rogers
Louisiana State University, Baton Rouge, La	(4)	Fred H. Fenn	Robert A. Crain	M. B. Voorhies
Louisville, University of, Louisville, Ky	(4)	H. T. Clark	O. M. Arehart	D. C. Jackson, Jr.
Maine, University of, Orono, Maine	(1)	A. E. Crockett	H. R. Mayers	Wm. E. Barrows, Jr.
Marquette University, 1200 Sycamore St., Milwaukee, Wis	(5)	H. W. Haase	G. C. Reichert	J. F. H. Douglas
Massachusetts Institute of Technology, Cambridge, Mass	(1)	R. H. Swingle	C. M. Twelves, Jr.	W. H. Timbie
Michigan College of Mining and Technology, Houghton, Michigan	(5)	Charles F. Sawyer	B. G. Swart	G. W. Swenson
Michigan State College, East Lansing, Mich.	(5)	R. L. Clark	G. A. Whitfield	L. S. Foltz
Michigan, University of, Ann Arbor, Mich	(5)	Charles W. Doane	Glen R. Severance	B. F. Bailey
Milwaukee, School of Engineering of, 163 East Wells St., Milwaukee, Wis	(5)	T. J. Coleman, Jr.	K. O. Werwath	Oscar Werwath
Minnesota, University of, Minneapolis, Minn	(5)	R. W. Fenton	W. M. Taylor	J. H. Kuhlmann
Mississippi Agricultural & Mechanical College, A. & M. College, Miss	(4)	W. F. Barksdale	A. H. Peale	L. L. Patterson
Missouri School of Mines & Metallurgy, Rolla, Mo	(7)	George W. Douglas	J. D. Shelton	I. H. Lovett
Missouri, University of, Columbia, Mo	(7)	L. G. Weiser	W. Sevchuk	M. P. Weinbach
Montana State College, Bozeman, Mont	(9)	E. B. Wilson	O. Van Horn	J. A. Thaler
Nebraska, University of, Lincoln, Neb	(6)	V. L. Bollman	W. E. Stewart	F. W. Norris
Nevada, University of, Reno, Nevada	(8)	A. McCullom	A. B. Chace	S. G. Palmer
Newark College of Engineering, 367 High St., Newark, N. J.	(3)	H. Harrison	A. L. Davis	J. C. Peet
New Hampshire, University of, Durham, N. H.	(1)	P. Nudd	D. Googins	L. W. Hitchcock
New Mexico, The University of, Albuquerque, New Mexico	(7)	F. A. Stortz, Jr.	W. I. Abbott	F. M. Denton
New York, College of the City of, 139th St. & Convent Ave., New York, N. Y.	(3)	Eugene J. Erdos	F. J. Wodicka	Harry Baum
New York University, University Heights, New York, N. Y.	(3)	N. G. Schutt	T. S. Humphrey	J. Loring Arnold
North Carolina State College, Raleigh, N. C.	(4)	H. W. Horney	E. R. Price	R. S. Fouraker
North Carolina, University of, Chapel Hills, N. C.	(4)	J. J. Alexander	F. R. Toms	J. E. Lear
North Dakota Agricultural College, State College Station, Fargo, N. D.	(6)	R. Stockstad	Robert Carlson	H. R. Rush
North Dakota, University of, University Station, Grand Forks, N. D.	(6)	R. W. Olson	G. E. Glass	H. F. Rice
Northeastern University, 316 Huntington Ave., Boston 17, Mass	(1)	R. W. Littlefield	R. J. Edwards	Wm. L. Smith
Notre Dame, University of, Notre Dame, Ind	(5)	E. G. Conroy	Ben South	J. A. Caparo
Ohio Northern University, Ada, Ohio	(2)	J. D. McGahan	R. I. Hartshorn	I. S. Campbell
Ohio State University, Columbus, Ohio	(2)	W. M. Webster	R. C. Moser	F. C. Caldwell
Ohio University, Athens, Ohio	(2)	Thomas A. Elder	E. R. McCoppin	A. A. Atkinson
Oklahoma A. & M. College, Stillwater, Okla	(7)	H. V. Anderson	E. F. Neal	Albrecht Naeter
Oklahoma, University of, Norman, Okla	(7)	E. E. Brady	C. W. Anthony	F. G. Tappan
Oregon State College, Corvallis, Oregon	(9)	B. G. Griffith	D. H. Moreland	F. O. McMillan
Pennsylvania State College, State College, Pa	(2)	W. C. Mason	Wallace J. Wood	L. A. Doggttt
Pennsylvania University of, Philadelphia, Pa	(2)	R. R. Creighton	N. Smith	C. D. Fawcett
Pittsburgh, University of, Pittsburgh, Pa	(2)	W. A. Aeberlie	G. L. Bolender	H. E. Dyche
Pratt Institute, Brooklyn, N. Y.	(3)	G. R. Glasscock	K. H. Stanger	A. L. Cook
Princeton University, Princeton, N. J.	(2)	C. F. Nesslage	N. T. Humphrey	Malcolm MacLaren
Purdue University, Lafayette, Indiana	(5)	P. C. Sandretto	R. T. Orth	A. N. Topping
Rensselaer Polytechnic Institute, Troy, N. Y.	(1)	Wm. Mayott	R. N. Palmer	F. M. Sebast
Rhode Island State College, Kingston, R. I.	(1)	K. K. Sperl	C. Pagella	Wm. Anderson
Rose Polytechnic Institute, Terre Haute, Ind	(5)	D. E. Henderson	J. H. Corp	C. C. Knipmeyer
Rutgers University, New Brunswick, N. J.	(3)	G. E. Weglener	E. R. Crawford	Paul S. Creager
Santa Clara, University of, Santa Clara, Calif	(8)	T. L. Selna	J. D. Gillis	L. J. Neuman
South Carolina, University of, Columbia, S. C.	(4)	G. H. Preacher	B. F. Karick	T. F. Ball
South Dakota State School of Mines, Rapid City, S. D.	(6)	H. E. Sattler	B. Hagmann	J. O. Kammerman
South Dakota, University of, Vermillion, S. D.	(6)	E. Johnson	E. E. Lovejoy	B. B. Brackett
Southern California, University of, Los Angeles, Calif	(8)	George Robertson	L. H. Hendrixson	Philip S. Biegler
Southern Methodist University, Dallas, Texas	(7)	Ben J. Beaird	D. J. Tucker	E. H. Flath
Stanford University, Stanford University, Calif	(8)	D. H. Ring	H. E. Hill	T. H. Morgan
Stevens Institute of Technology, Hoboken, N. J.	(3)	F. C. Gilman	G. Habach	F. C. Stockwell
Swarthmore College, Swarthmore, Pa	(2)	George B. Hoadley	David C. Haskell	Lewis Fussell
Syracuse University, Syracuse, N. Y.	(1)	D. A. MacGregor	M. J. Wright	C. W. Henderson
Tennessee, University of, Knoxville, Tenn	(4)	F. P. Elam	A. M. Howery	Joseph G. Tarboux
Texas, A. & M. College of, College Station, Texas	(7)	S. L. Moseley	T. M. Sowell	H. C. Dillingham
Texas Technological College, Lubbock, Texas	(7)	Wm. E. Street	W. L. Pearson	Wm. J. Miller
Texas, University of, Austin, Texas	(7)	E. W. Toepperwein	William Webber	J. A. Correll
Utah, University of, Salt Lake City, Utah	(9)	L. A. Moore	S. Blomquist	J. H. Hamilton
Vermont, University of, Burlington, Vt	(1)	F. E. Beckley	A. E. Merrill	L. P. Dickinson
Virginia Military Institute, Lexington, Va	(4)	W. T. Saunders	A. S. Britt, Jr.	S. W. Anderson
Virginia Polytechnic Institute, Blacksburg, Va	(4)	L. Backer	C. V. West	Claudius Lee
Virginia, University of, University, Va	(4)	H. R. Holt	C. H. Dickinson	W. S. Rodman
Washington, State College of, Pullman, Wash	(9)	Joseph Dodds	F. S. Allan	R. D. Sloan
Washington University, St. Louis, Mo	(7)	Wm. L. Knaus	C. Horstman	H. G. Hake
Washington, University of, Seattle, Wash	(9)	K. E. Hammer	J. E. Burrell	G. L. Hoard
Washington & Lee University, Lexington, Va	(4)			R. W. Dickey
West Virginia University, Morgantown, W. Va	(2)	C. E. Moyers	G. H. Hollis	A. H. Forman
Wisconsin, University of, Madison, Wis	(5)	G. H. Brown	A. N. O'Neill	C. M. Jansky
Worcester Polytechnic Institute, Worcester, Mass	(1)	E. C. Milde	C. S. Greco	E. W. Starr
Wyoming, University of, Laramie, Wyoming	(6)	R. A. Buckmaster	J. E. Surline	G. H. Sechrist
Yale University, New Haven, Conn	(1)	F. H. Eastman	A. K. Wing, Jr.	R. G. Warner
Total 106				

AFFILIATED STUDENT SOCIETY

Brown Engineering Society, Brown University, Providence, R. I.		R. E. Tanner		

ORDER FORM FOR REPRINTS OF PAPERS ABRIDGED IN THIS ISSUE OF THE JOURNAL*

(March 1930)

Number	Author	Title
☐ **29-150**	W. H. Harrison	Recent Developments in Toll Telephone Service
☐ **29-156**	C. M. Laffoon	Increased Voltages for Synchronous Machines
☐ **29-164**	P. L. Alger, E. H. Freiburghouse, and D. D. Chase	Double Windings for Turbine Alternators
☐ **30- 11**	L. V. Bewley	Induced Voltage of Electrical Machines
☐ **30- 12**	S. M. Dean	The Fundamental Plan of Power Supply of the Detroit Edison Company
☐ **30- 15**	L. S. Coggeshall	Submarine Telegraphy in the Post War Decade
☐ **30- 17**	Morris Stone and J. G. Ritter	Electrically Welded Structures under Dynamic Stress
☐ **30- 19**	J. B. Whitehead and R. H. Marvin	The Conductivity of Insulating Oils
☐ **30- 26**	R. R. Benedict	Behavior of Dielectrics
☐ **30- 39**	A. M. Rossman	The Metal-Clad Switchgear at State Line Station
☐ **30- 46**	J. J. Smith	Telephone Interference from A-C. Generators Feeding Directly on Line with Neutral Grounded

*Members, Enrolled Students, and JOURNAL subscribers are entitled to one complete copy of each paper free of charge; additional copies 25 cents each.

Name...

Address...

Please order reprints by number. *Address* **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

DIGEST OF CURRENT INDUSTRIAL NEWS

NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies

Circuit Breakers.—Bulletin 1705-B, 20 pp. Describes type CL carbon circuit breakers. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Penna.

Motor Control.—Bulletin, 32 pp., "Practical Pointers on the Selection of Motor Control." Cutler-Hammer, Inc., 12th Street & St. Paul Ave., Milwaukee, Wis.

Steam Turbines.—Bulletin, 112 pp. Describes the construction of steam turbines in the Mülheimer plant of the Siemens-Schuckertwerke Akt., Berlin-Siemensstadt, Germany.

Railway Signal Accessories.—Catalog GEA-610, 40 pp. Describes electrical material used in the railway-signal field other than that made solely for signal purposes. General Electric Company, Schenectady, N. Y.

Trench Digging Machines.—Catalog 10, 32 pp. Describes trench digging apparatus widely used by public utilities as well as accessories for underground conduit work. Cleveland Trencher Company, 20100 St. Clair Avenue, Cleveland, Ohio.

Instruments.—Bulletin 210. Describes portable direct-current ammeters, milli-ammeters, voltmeters, milli-voltmeters, volt-ammeters, galvanometers, circuit testers, shunts, multipliers, etc. Roller-Smith Company, 12 Park Place, New York.

G-E Motion Pictures.—Bulletin GES-402A, 28 pp. Describes motion pictures and illustrated lectures illustrating the development and application of electrical products. General Electric Company, Schenectady, N. Y.

Resistance Measuring Instruments.—Bulletin 300. Describes various types of instruments for resistance measurements, namely types COM, GOM and SOM ohmmeters and type HTD circuit tester. Roller-Smith Company, 12 Park Place, New York.

Insulating Oil.—Bulletin GEA-1180, 12 pp. Describes Transil oil No. 10-C for use in all General Electric oil-immersed transformers, induction voltage regulators, oil fuse cutouts, industrial control devices and a-c. aluminum-cell lightning arresters. It also can be used with certain types of circuit breakers. General Electric Company, Schenectady, N. Y.

Splicing Tape.—Bulletin, 12 pp., Describes "Twin Tape," combining rubber and friction tape in one and eliminating the necessity of separate rubber and friction tapes in taping joints and splices. The new tape has been approved by the Underwriters' Laboratories of New York and Chicago and many of the leading public utilities. Dexter Rubber Manufacturing Co., 2 West 45th Street, New York.

Air Break Switches.—Bulletin 31, 16 pp. Describes Pacific Electric type TX-5 switches. These new switches are of the vertical break type, and among the outstanding features claimed for them are that parts are interchangeable for any method of mounting; standard bus or switch insulators; no cast copper members are used to conduct current for the blade through the hinge to the terminal; full floating, self-aligning contacts. Pacific Electric Mfg. Corp., 5815 Third Street, San Francisco, Cal.

NOTES OF THE INDUSTRY

New England Sales Manager for W. N. Matthews Corp.—Ernest H. Bradley has been appointed New England sales manager of the W. N. Matthews Corporation, St. Louis. His headquarters will be in the Statler Building, Boston, Mass. Mr. Bradley replaces Hugo Van Rosen, who has taken a residence in Chicago.

William B. Lawson, director of sales of the International Nickel Company of Canada, Ltd., has resigned, and has been elected vice-president and a director of the Harshaw Chemical Company, Cleveland. Mr. Lawson brings to the Harshaw Chemical Company the experience of twenty-five years' connection with the Nickel Company during which he became well known in the metal and chemical industries generally both in the United States and Europe.

Roller-Smith Company Appointments.—The Roller-Smith Company, 12 Park Place, New York, announces the appointment of M. W. Seymour in the New York office as sales engineer. For several months previously Mr. Seymour has been located at the company's works in Bethlehem, Penna. H. D. Stier, 101 Marietta Street, Atlanta, now represents the Roller-Smith Company in a number of the southern states. The H. N. Muller Company, First National Bank Building, Pittsburgh, is now representative for western Pennsylvania, West Virginia and the Youngstown District in Ohio. Associated with H. N. Muller are H. E. Ransford and F. E. Harper.

Monel Metal Motion Picture.—A two-reel picture telling the story of Monel metal has been released by the Rothacker Film Corporation, of Chicago. The film shows the preparation of the metal in its various commercial forms at Huntington, West Virginia, and traces its various uses in more than a score of different industries. Also shown in the film is the tapping of an eleven-ton furnace with the molten metal being poured at a temperature of 3000 degrees Fahrenheit. This is the largest non-ferrous electric furnace in the world. Requests for the loan of the picture should be addressed to the International Nickel Company, 67 Wall Street, New York.

Large Motor Orders for Electrical Machinery Mfg. Co.—The Electric Machinery Manufacturing Company, Minneapolis, has been awarded an order for ten 300 hp. and four 500 hp. synchronous motors to be installed in the Cambria plant of the Bethlehem Steel Corporation. Another order has been received from the Maine Seaboard Paper Company of Augusta, for five 3500 hp. synchronous motors for driving pulp grinders and two 150 kw. synchronous motor generator sets.

A New Motor.—The Century Electric Company, St. Louis, Mo., has recently developed a line of totally enclosed, fan-cooled motors. The new motor is of squirrel-cage induction type and, in most of the ratings, has the size advantages of a standard open-rated motor, plus the added advantage of full protection to the stator, rotor and other internal parts of the motor, all of which are completely isolated from the outside air. This effectively prevents the entrance of dust and dirt where it is present in abnormal quantities, or where its nature and character would have a deteriorating effect upon the windings or rotor. The motor is completely enclosed with ribbed cast-iron coil guards and there are no rubbing seals or air gaps, all machined fits. Provisions are made to circulate the air within the motor shell and transfer the heat to the radiating surfaces, where it is carried away and dissipated by the cooling air.

Meter Accuracy in New York City.—Of the 2,188,121 meters on the lines of The New York Edison Company, Brooklyn Edison Company, United Electric Light and Power Company, New York and Queens Electric Light and Power Company, and the Yonkers Electric Light and Power Company, 310,017 were tested in 1929, and only 694 were found to be operating fast, or to the disadvantage of the consumers, according to Matthew S. Sloan, president. A total of 302,231 were operating accurately according to prescribed legal standards, and 7019 were slow, or registering to the disadvantage of the companies, the tests showed. The gain in number of meters on The New York Edison System in 1929 was 68,485. The greatest gain was in Brooklyn, with 23,619. In Queens the increase was 20,550, in Yonkers, 2921 and in Manhattan and Bronx, 21,395. The increase in meters is not an accurate index to growth in congested areas like Manhattan, where several six-story buildings containing a number of meters may be replaced by a skyscraper with fewer meters but greatly increased consumption of current.